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FIFTEENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1903.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
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APPROVED BY

THE STATE BOARD OF PUBLICATION.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

OFFICERS.

Henry H. Goodell, LL.D.,	*Director.*
William P. Brooks, Ph.D.,	*Agriculturist.*
George E. Stone, Ph.D.,	*Botanist.*
Charles A. Goessmann, Ph.D., LL.D.,	*Chemist* (fertilizers).
Joseph B. Lindsey, Ph.D.,	*Chemist* (foods and feeding).
Charles H. Fernald, Ph.D.,	*Entomologist.*
Frank A. Waugh, M.S.,	*Horticulturist.*
J. E. Ostrander, C.E.,	*Meteorologist.*
Henry T. Fernald, Ph.D.,	*Associate Entomologist.*
Henry M. Thomson, B.Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B.Sc.,	*Assistant Botanist.*
Henri D. Haskins, B.Sc.,	*Assistant Chemist* (fertilizers).
Daniel L. Cleaves, B.Sc.,	*Assistant Chemist* (fertilizers).
James E. Halligan, B.Sc.,	*Assistant Chemist* (fertilizers).
Edward B. Holland, M.Sc.,	*First Chemist* (foods and feeding).
Philip H. Smith, B.Sc.,	*Assistant Chemist* (foods and feeding).
——— ———	*Assistant Chemist* (foods and feeding).
George A. Drew, B.Sc.,	*Assistant Horticulturist.*
——— ———	*Assistant Horticulturist.*
Stephen C. Bacon,	*Observer.*

The co-operation and assistance of farmers, fruit growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

The following bulletins and reports are still in stock and can be furnished on demand: —

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 54. Fertilizer analyses.
No. 57. Fertilizer analyses.
No. 64. Analyses of concentrated feed stuffs.
No. 67. Grass thrips; treatment for thrips in greenhouses.
No. 68. Fertilizer analyses.
No. 69. Rotting of greenhouse lettuce.
No. 70. Fertilizer analyses.
No. 72. Summer forage crops.
No. 73. Orchard experiments; fertilizers for fruits; thinning fruits; spraying fruits.
No. 75. Fertilizer analyses.
No. 76. The imported elm-leaf beetle.
No. 77. Fertilizer analyses.
No. 78. Concentrated feed stuffs.
No. 79. Growing China asters.
No. 80. Fungicides; insecticides; spraying calendar.
No. 81. Fertilizer analyses; treatment of barnyard manure with absorbents; trade values of fertilizing ingredients.
No. 82. Orchard management; cover crops in orchards; pruning of orchards; report on fruits.
No. 83. Fertilizer analyses.
No. 84. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Special bulletin, — The coccid genera Chionaspis and Hemichionaspis.
Index, 1888–95.
Annual reports for 1897, 1898, 1899, 1900, 1901.

Of the other bulletins, a few copies remain, which can be supplied only to complete sets for libraries.

An outline of the more important work undertaken and the results secured is all the limits of our space will allow. There have been no serious outbreaks of insects during the year. The gypsy moth and brown-tail moth have continued their ravages, while the elm-leaf beetle has been found more particularly in the north-eastern part of the State. Extensive experiments on the best methods of treatment of the San José scale under New England conditions have been carried on. Six hundred trees have been under observation, and the results of different treatment have been verified by repeated investigations. A bibliographical catalogue of all the scale insects of the world is about completed and will soon be in press.

It has been found that to prevent the mildew on cucumbers grown under glass they should be started as late as possible in the season, and that a dry atmosphere in the house would largely prevent the spread of mildew. Apple-leaf spots were found not to be due to a fungus, as at first supposed, but to exposure to a freezing temperature and to subsequent cold, wet weather. The effect of spraying for leaf spot on linden and elm has been very marked, the foliage being more abundant and remaining green longer. So far as production of fruit is concerned, the experiment of planting cucumbers, watermelons and tomatoes on the edge of fields under tent cloth has proved a failure, because no provision was made for fertilizing the flowers. For sterilizing soil, two-inch pipe with three-sixteenths or one-fourth perforations gives better results than one-inch pipe. Sterilization of soil has marked beneficial results on germination of seeds and subsequent growth of plants; but tomato seeds seem to be an exception to this rule.

In addition to the regular work of the dairy division, with its 3,240 substances analyzed, 2,344 pieces of glass were tested for accuracy. Investigations have been on the following lines: (*a*) examination of butter fat in connection with feeding experiments, to note the effect of various feed constituents upon its character; (*b*) the improvement of methods for determination of the pentosans and starch in feed stuffs; (*c*) determination of the availability of organic nitrogen in fertilizing materials; (*d*) to ascertain the effect of two different milk-condensing processes on the nitrogenous bodies of milk. The pentosans were found to be fully as digestible as the other fodder groups in case of upland hays and most by-products, but rather less digestible in swale hay, salt grasses and wheat bran. A mixture of winter wheat and sand or hairy vetch was found to be an early and desirable spring green fodder, but for the cost of vetch seed.

In the agricultural division, besides a carefully planned series of experiments to throw light on some of the numerous conditions determining productiveness, — chiefly as affected by different manures and fertilizers, either alone or in a wide variety of combinations, — variety tests with potatoes have been undertaken, with the result that in productiveness the following varieties stood first in the order given : Beauty of Hebron, I. X. L., Steuben, Early Nancy, Million Dollar, Ensign Bagley, Early Rose, Gem of Aroostook, and Daughter of Early Rose.

The details of the experiments thus briefly outlined may be found in the reports of the several divisions herewith submitted.

ANNUAL REPORT

OF GEORGE F. MILLS, *Treasurer* OF THE HATCH EXPERIMENT STATION OF MASSACHUSETTS AGRICULTURAL COLLEGE,

For the Year ending June 30, 1902.

Cash received from United States Treasurer,		$15,000 00
Cash paid for salaries,	$7,366 88	
for labor,	2,224 12	
for publications,	1,205 64	
for postage and stationery,	359 37	
for freight and express,	60 57	
for heat, light, water and power,	765 27	
for seeds, plants and sundry supplies,	530 60	
for fertilizers,	444 25	
for feed stuffs,	210 83	
for library,	140 53	
for tools, implements and machinery,	538 16	
for furniture and fixtures,	28 95	
for scientific apparatus,	59 24	
for live stock,	410 93	
for traveling expenses,	150 57	
for contingent expenses,	131 15	
for building and repairs,	372 94	
		$15,000 00

Cash received from State Treasurer,	$11,200 00	
from fertilizer fees,	3,405 00	
from farm products,	2,274 66	
from miscellaneous sources,	2,319 66	
		$19,199 32

Cash paid for salaries,	$11,966 73
for labor,	2,012 21
for publications,	406 36
for postage and stationery,	321 22
for freight and express,	132 93
for heat, light, water and power,	639 40
Amount carried forward,	$15,478 85

Amount brought forward,		$15,478 85	
Cash paid	for chemical supplies,	354 53	
	for seeds, plants and sundry supplies,	141 69	
	for fertilizers,	428 05	
	for feed stuffs,	784 50	
	for library,	143 87	
	for tools, implements and machinery,	87 05	
	for furniture and fixtures,	16 40	
	for scientific apparatus,	443 97	
	for live stock,	253 09	
	for traveling expenses,	437 45	
	for contingent expenses,	114 05	
	for building and repairs,	515 82	
			$19,199 32

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1902; that I have found the books well kept and the accounts correctly classified as above; and that the receipts for the year are shown to be $34,199.32, and the corresponding disbursements $34,199.32. All the proper vouchers are on file. These have been examined by me and have been found to be correct, there being no balance on accounts of the fiscal year ending June 30, 1902.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 26, 1902.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.

Assistants: HENRI D. HASKINS, JAMES E. HALLIGAN, DANIEL L. CLEAVES.

Part I. — Report on Official Inspection of Commercial Fertilizers.
Part II. — Report on General Work in the Chemical Laboratory.

Part I. — Report on Official Inspection of Commercial Fertilizers and Agricultural Chemicals during the Season of 1902.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 64; of these, 37 have offices for the general distribution of their goods in Massachusetts, 9 in New York, 8 in Connecticut, 3 in Vermont, 1 in Rhode Island, 3 in Canada, 1 in New Jersey, 1 in Maryland, 1 in Ohio and 1 in Illinois.

Two hundred and eighty-three brands of fertilizer, including chemicals, have been licensed in the State during the year. Five hundred and four samples of fertilizers have thus far been collected in the general markets by experienced assistants in the station.

Four hundred and fifty-one samples were analyzed at the close of November, 1902, representing two hundred and seventy-three distinct brands of fertilizer. These analyses were published in two bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 83, July; and No. 84, November, 1902.

From the above statement it will be noticed that there is a marked increase in the amount of work which is involved in the official inspection of commercial fertilizers from year to year. Four more manufacturers were recorded as having secured licenses for the sale of their goods in Massachusetts in 1902 than in the preceding year. Seventeen more brands of fertilizers were licensed and fifty-five more collected during the past season than in the previous year.

Below will be found an abstract of the results of analyses of official commercial fertilizers for the years 1901 and 1902: —

	1901.	**1902.**
(*a*) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee,	7	7
Number with two elements above the highest guarantee, . . .	15	20
Number with one element above the highest guarantee, ...	51	83
Number with three elements between the lowest and highest guarantee,	142	183
Number with two elements between the lowest and highest guarantee,	91	87
Number with one element between the lowest and highest guarantee, .	39	54
Number with three elements below the lowest guarantee, . . .	–	3
Number with two elements below the lowest guarantee, . . .	8	18
Number with one element below the lowest guarantee, ...	86	67
(*b*) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee, . . .	7	10
Number with one element above the highest guarantee, ...	12	22
Number with two elements between the lowest and highest guarantee,	24	16
Number with one element between the lowest and highest guarantee,	14	13
Number with two elements below the lowest guarantee, ...	2	4
Number with one element below the lowest guarantee, ...	14	19
(*c*) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee, ...	7	9
Number between lowest and highest guarantee, ...	18	14
Number below lowest guarantee, ...	9	20

The quality of our commercial fertilizers for the past year has been fully as good as in the preceding years, and, with few exceptions, the commercial value of the fertilizer has not suffered where a discrepancy has occurred between the results of analysis and the manufacturer's guarantee. This would indicate that it was the manufacturer's aim to furnish an article fully equal to his guarantee of composition, and, where a difference has occurred between the analysis and guarantee, that poor mixing is responsible for the discrepancy. It is self-evident that those fertilizers should be selected for general use which furnish the greatest amount of nitrogen, potash and phosphoric acid, in a suitable and available form, for the same money.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1901 and 1902 (Cents per Pound).

	1901.	1902.
Nitrogen in ammonia salts,	16.50	16.50
Nitrogen in nitrates,	14.00	15.00
Organic nitrogen in dry and fine-ground fish, meat, blood and in high-grade mixed fertilizers.	16.00	16.50
Organic nitrogen in fine bone and tankage,	16.00	16.00
Organic nitrogen in medium bone and tankage,	12.00	12.00
Phosphoric acid soluble in water,	5.00	5.00
Phosphoric acid soluble in ammonium citrate,	4.50	4.50
Phosphoric acid in fine-ground fish, bone and tankage,	4.00	4.00
Phosphoric acid in cotton-seed meal, castor pomace and wood ashes,	4.00	4.00
Phosphoric acid in coarse fish, bone and tankage,	3.00	3.00
Phosphoric acid insoluble (in water and in ammonium citrate) in mixed fertilizers.	2.00	2.00
Potash as sulfate (free from chlorides),	5.00	5.00
Potash as muriate,	4.25	4.25

A comparison of the above trade values for 1901 and 1902 shows that the market cost of the different essential elements of plant food remains the same as in 1901, with the exception of nitrogen in form of nitrates and the higher grades of organic nitrogenous fertilizing materials, which show a somewhat higher cost, as compared with the previous year.

The trade values of fertilizing ingredients in raw materials and chemicals are based on the market cost, during the six months preceding March, 1902, of standard raw materials which enter largely into the manufacture of commercial fertilizers found in our markets. The following is a partial list of such materials : —

- Sulfate of ammonia.
- Nitrate of soda.
- Azotine.
- Dried blood.
- Cotton-seed meal.
- Linseed meal.
- Bone and tankage.
- Castor pomace.
- Dry ground fish.
- Dry ground meat.
- Dissolved bones.
- Acid phosphate.
- Refuse bone-black.
- Ground phosphate rock.
- High-grade sulfate of potash.
- Sulfate of potash and magnesia.
- Muriate of potash.
- Kainit.
- Sylvinite.
- Crude saltpetre.

As definite instructions have been given from time to time regarding the calculation of the approximate commercial value of fertilizers, no attempt is here made for the discussion of that matter.

Table A, following, gives the average analysis of officially collected fertilizers for 1902 ; Table B gives a compilation of analyses of commercial fertilizers for the year 1902, showing the maximum, minimum and average percentages of the different essential elements of plant food in special crop fertilizers, so called.

TABLE A. — *Average Analysis of Officially Collected Fertilizers for 1902.*

NATURE OF MATERIAL.	Moisture.	NITROGEN IN ONE HUNDRED POUNDS.		PHOSPHORIC ACID IN ONE HUNDRED POUNDS.							POTASSIUM OXIDE IN ONE HUNDRED POUNDS.	
							TOTAL.		AVAILABLE.			
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
Complete fertilizers,	11.14	2.29	2.10	4.57	3.57	2.66	10.64	9.29	8.03	7.37	4.96	4.69
Ground bones,	6.92	3.16	2.85	–	9.44	15.12	25.04	22.99	9.44	–	–	–
Tankage,	10.66	3.82	3.56	–	9.01	8.78	17.79	18.00	9.01	–	–	–
Dissolved bone-black,	11.06	–	–	10.16	5.24	1.97	17.68	16.00	15.71	15.00	–	–
Acid phosphate,	10.92	–	–	9.89	4.82	2.40	17.32	15.33	14.72	13.50	–	–
Wood ashes,	13.19	–	–	–	–	–	1.48	1.30	–	–	6.14	4.70
Cotton-seed meal,	7.11	6.48	6.75	–	–	–	–	–	–	–	–	–
Flax meal,	10.43	6.17	6.08	–	–	–	–	–	–	–	–	–
Nitrate of soda,	1.97	15.17	15.40	–	–	–	–	–	–	–	–	–
Sulfate of ammonia,	.82	22.02	19.00	–	–	–	–	–	–	–	–	–
High-grade sulfate of potash,	.81	–	–	–	–	–	–	–	–	–	49.02	48.00
Low-grade sulfate of potash,	.23	–	–	–	–	–	–	–	–	–	25.85	26.00
Muriate of potash,	2.27	–	–	–	–	–	–	–	–	–	50.32	50.00
Kainit,	4.37	–	–	–	–	–	–	–	–	–	12.08	12.00

TABLE B. — *Compilation of Analyses of Commercial Fertilizers for the Year 1902.*

NAME OF FERTILIZER.	Moisture.	NITROGEN IN ONE HUNDRED POUNDS.			TOTAL PHOSPHORIC ACID IN ONE HUNDRED POUNDS.			AVAILABLE PHOSPHORIC ACID IN ONE HUNDRED POUNDS.			POTASSIUM OXIDE IN ONE HUNDRED POUNDS.		
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
Corn fertilizer,	12.27	3.48	1.04	2.35	14.20	9.52	11.22	10.65	6.32	8.55	8.88	1.80	4.49
Fruit and vine fertilizer,	9.75	3.44	2.07	2.55	11.82	9.60	10.92	8.70	7.96	8.23	6.78	5.04	5.88
Grain fertilizer,	10.60	6.64	1.82	3.01	17.28	8.88	11.29	10.50	5.22	7.86	12.08	2.20	6.49
Grass fertilizer,	8.56	7.72	2.48	4.08	17.28	5.02	9.24	9.84	2.90	5.87	12.08	2.06	5.86
Market-garden fertilizer,	12.60	3.61	2.02	2.69	12.12	7.70	10.47	9.72	6.30	8.34	10.40	2.18	5.89
Potato fertilizer,	10.87	4.88	1.05	2.54	12.84	7.18	10.58	10.94	4.24	8.39	10.48	2.90	5.30
Tobacco fertilizer,	8.32	6.68	1.76	3.91	13.71	5.38	10.36	11.59	2.84	7.66	14.15	1.54	7.74

The writer wishes to call special attention to Table B, on the preceding page. A comparison of the results in this compilation of analyses of so-called special crop fertilizers reveals a wide difference between the maximum and minimum amount of nitrogen, phosphoric acid and potassium oxide claimed and found in the different brands of commercial fertilizers. In the different brands of tobacco fertilizers, for instance, there is a difference of 4.92 between the highest and lowest percentage of nitrogen, a difference of 8.75 between the maximum and minimum percentage of available phosphoric acid, and a difference of 12.61 between the mean and extreme percentage of potassium oxide which was found. A correspondingly great difference will be observed between the maximum and minimum percentages of plant food found in the several special crop fertilizers which have been compiled in the table. The average farmer is apt to lay too much stress upon the trade name of a fertilizer, and oftentimes buys an inferior article when guided wholly by the name under which it is sold.

There are many things to be taken into consideration in the judicious selection of a fertilizer for growing special crops. The physical and chemical character of the soil and sub-soil, the previous management of the soil and the system of crop rotation employed should all enter into consideration when selecting a fertilizer. A study of the soil should be made by simple local experiments with the different kinds and forms of plant food, to find what elements have become depleted; when these facts have become established, then supply the wants of the soil in the most suitable and economical manner. When the character of a soil is not known and its wants are not manifested, it is advisable to use a fertilizer more nearly corresponding to what a chemical analysis of the crop shows is required for its proper development. For the purpose of illustrating how the chemical composition of a crop may serve as a guide in the compounding of a commercial fertilizer, an example is here inserted. We find the average analysis of potatoes (see compilation of analyses of fruits, garden crops, etc., in annual report of this department for the year 1901) is as follows: —

	Parts per Thousand.
Phosphoric acid,	.70
Potassium oxide,	2.90
Nitrogen,	2.10

The relative proportion of phosphoric acid, potassium oxide and nitrogen present, according to this analysis, is: —

	Parts per Thousand.
Phosphoric acid,	1.00
Potassium oxide,	4.10
Nitrogen,	3.00

In other words, for every pound of phosphoric acid removed from the soil by a crop of potatoes there are 4.1 pounds of potassium oxide and 3 pounds of nitrogen removed. A fertilizer supplying the essential elements of plant food in this proportion would, therefore, under the above-stated conditions, be more suitable to use, as far as potassium oxide and phosphoric acid are concerned, as these elements are supplied only by the soil, while nitrogen is supplied in part by atmospheric sources.

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State during the Past Year (May 1, 1902, to May 1, 1903), and the Brands licensed by Each.

The American Agricultural Chemical Co., Boston, Mass.: —
- Nitrate of Soda.
- Muriate of Potash.
- High-grade Sulfate of Potash.
- Double Manure Salt.
- Dry Ground Fish.
- Fine-ground Bone.
- Dissolved Bone-black.
- Plain Superphosphate.
- Sulfate of Ammonia.
- Kainit.
- High-grade Fertilizer with Ten Per Cent. Potash.
- Tobacco Starter and Grower.

The American Agricultural Chemical Co. (Bradley Fertilizer Co., branch), Boston, Mass.: —
- Bradley's X. L. Superphosphate.
- Bradley's Potato Manure.
- Bradley's Potato Fertilizer.

The American Agricultural Chemical Co. — *Con.*
- Bradley's Complete Manure for Potatoes and Vegetables.
- Bradley's Corn Phosphate.
- Bradley's Eclipse Phosphate.
- Bradley's Niagara Phosphate.
- Bradley's English Lawn Fertilizer.
- Bradley's Complete Manure with Ten Per Cent. Potash.
- Bradley's Complete Manure for Corn and Grain.
- Bradley's Complete Manure for Top-dressing Grass and Grain.
- Bradley's Grass and Lawn Top-dressing.
- Breck's Lawn and Garden Dressing.
- Brightman's Fish and Potash.
- Church's Fish and Potash.
- Bradley's Seeding-down Manure.

The American Agricultural Chemical Co. (Clark's Cove Fertilizer Co., branch), Boston, Mass.: —
- Clark's Cove Bay State Fertilizer.
- Clark's Cove Bay State Fertilizer, G. G.
- Clark's Cove Potato Manure.
- Clark's Cove Potato Fertilizer.
- Clark's Cove Great Planet Manure.
- Clark's Cove King Philip Guano.

The American Agricultural Chemical Co. (Crocker Fertilizer and Chemical Co., branch), Buffalo, N. Y.: —
- Crocker's Potato, Hop and Tobacco Phosphate.
- Crocker's Corn Phosphate.
- Crocker's New Rival Phosphate.
- Crocker's General Crop Phosphate.
- Crocker's A. A. Complete Manure.

The American Agricultural Chemical Co. (Cumberland Bone Phosphate Co., branch), Boston, Mass.: —
- Cumberland Superphosphate.
- Cumberland Potato Fertilizer.

The American Agricultural Chemical Co. (L. B. Darling Fertilizer Co., branch), Pawtucket, R. I.: —
- Blood, Bone and Potash.
- Potato and Root Crop Manure.
- Complete Ten Per Cent. Manure.
- Potato Manure.
- Farm Favorite.

The American Agricultural Chemical Co. (H. J. Baker & Bro., branch), New York, N. Y.: —
- Baker's Complete Potato Manure.
- Baker's A. A. Ammoniated Phosphate.

The American Agricultural Chemical Co. (Great Eastern Fertilizer Co., branch), Rutland, Vt.: —
- Northern Corn Special.
- Grass and Oats Fertilizer.
- General Fertilizer.
- Garden Special.
- Vegetable Vine and Tobacco.

The American Agricultural Chemical Co. (Pacific Guano Co., branch), Boston, Mass.: —
- Pacific High-grade General.
- Soluble Pacific Guano.
- Pacific Potato Special.
- Pacific Nobsque Guano.

The American Agricultural Chemical Co. (Packers' Union Fertilizer Co., branch), Rutland, Vt.: —
- Animal Corn Fertilizer.
- Potato Manure.
- Universal Fertilizer.
- Wheat, Oats and Clover Fertilizer.
- Gardener's Complete Manure.

The American Agricultural Chemical Co. (Quinnipiac Co., branch), Boston, Mass.: —
- Quinnipiac Onion Manure.
- Quinnipiac Phosphate.
- Quinnipiac Potato Manure.
- Quinnipiac Corn Manure.
- Quinnipiac Market-garden Manure.
- Quinnipiac Havana Tobacco Fertilizer.
- Quinnipiac Climax Phosphate.
- Quinnipiac Potato Phosphate.
- Quinnipiac Dissolved Bone.

The American Agricultural Chemical Co. (Read Fertilizer Co., branch), New York, N. Y.: —
- Read's Farmers' Friend.
- Read's Practical Potato Special.
- Read's Vegetable and Vine.
- Read's High-grade Farmers' Friend.
- Read's Standard.

The American Agricultural Chemical Co. (Standard Fertilizer Co., branch), Boston, Mass.: —
- Standard Fertilizer.
- Standard Guano.
- Standard Complete Manure.
- Standard Special for Potatoes.

The American Agricultural Chemical Co. (Henry F. Tucker Co., branch), Boston, Mass.: —
- Tucker's Original Bay State Bone Superphosphate.
- Tucker's Special Potato Fertilizer.

The American Agricultural Chemical Co. (Williams & Clark Fertilizer Co., branch), Boston, Mass.: —
- Williams & Clark's High-grade Special.
- Williams & Clark's Americus Phosphate.
- Williams & Clark's Potato Phosphate.

The American Agricultural Chemical Co. — *Con.*
  Williams & Clark's Corn Phosphate.
  Williams & Clark's Potato Manure.
  Williams & Clark's Royal Bone Phosphate.
  Williams & Clark's Prolific Crop Producer.

The American Agricultural Chemical Co. (M. E. Wheeler & Co., branch), Rutland, Vt.: —
  Corn Fertilizer.
  Potato Manure.
  Superior Truck Fertilizer.
  Bermuda Onion Grower.
  Grass and Oats Fertilizer.
  Havana Tobacco Fertilizer.

W. H. Abbott, Holyoke, Mass.: —
  Animal Fertilizer.
  Eagle Brand.
  Tobacco Fertilizer.

The Abbott & Martin Rendering Co., Columbus, Ohio: —
  Abbott's Tobacco and Potato Special.

The American Cotton Oil Co., New York, N. Y.: —
  Cotton-seed Meal.
  Cotton-seed Hull Ashes.

American Linseed Co., New York, N. Y.: —
  Cleveland Flax Meal.

Armour Fertilizer Works, Baltimore, Md.: —
  Blood, Bone and Potash.
  Ammoniated Bone with Potash.
  Grain Grower.
  All Soluble.
  High-grade Potato.
  Bone Meal.

H. J. Baker & Bro., New York, N. Y.: —
  Castor Pomace.

Bartlett & Holmes, Springfield, Mass.: —
  Animal Fertilizer.
  Pure Ground Bone.
  Tankage.

Berkshire Fertilizer Company, Bridgeport, Conn.: —
  Berkshire Complete Fertilizer.
  Berkshire Ammoniated Bone Phosphate.
  Berkshire Potato and Vegetable Phosphate.

Joseph Breck & Sons, Boston, Mass.: —
  Breck's Market Garden Manure.

Bowker Fertilizer Co., Boston, Mass.: —
  Stockbridge Special Manures.
  Bowker's Hill and Drill Phosphate.
  Bowker's Farm and Garden Phosphate.
  Bowker's Lawn and Garden Dressing.
  Bowker's Potato and Vegetable Fertilizer.
  Bowker's Fish and Potash "Square Brand."
  Bowker's Potato Phosphate.
  Bowker's Sure Crop Phosphate.
  Bowker's High-grade Fertilizer.
  Bowker's Bone and Wood Ash Fertilizer.
  Bowker's Superphosphate.
  Bowker's Ground Bone.
  Gloucester Fish and Potash.
  Dissolved Bone-black.
  Nitrate of Soda.
  Muriate of Potash.
  Sulfate of Potash.
  Dried Blood.
  Wood Ashes.
  Fine Dry Ground Fish.
  Bone, Blood and Potash.
  Fish and Potash D Brand.
  Bristol Fish and Potash.
  Corn Phosphate.
  Tobacco Ash Elements.
  Early Potato Manure.
  Sulfate of Ammonia.

Butchers' Rendering Co., Fall River, Mass.: —
  Tankage.

Chas. M. Cox & Co., Boston, Mass.: —
  Cotton-seed Meal.

E. Frank Coe Co., New York, N. Y.: —
  E. Frank Coe's High-grade Ammoniated Bone Superphosphate.
  E. Frank Coe's Gold Brand Excelsior Guano.

E. Frank Coe Co. — *Con.*
  E. Frank Coe's Tobacco and Onion Fertilizer.
  E. Frank Coe's Bay State Phosphate.
  E. Frank Coe's F. P. Fish and Potash.
  American Farmers' Market Garden Special.
  American Farmers' Complete Potato.
  American Farmers' Corn King.
  Excelsior Potato Fertilizer.
  Columbian Corn Fertilizer.
  Columbian Potato Fertilizer.
  New Englander Corn Fertilizer.
  New Englander Potato Fertilizer.
  Columbian Bone Superphosphate.
  X. X. X. Ground Bone.
  Red Brand Excelsior Guano.

John C. Dow & Co., Boston, Mass.: —
  Dow's Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
  Imperial Liquid Plant Food.
  Imperial Liquid Grass Fertilizer.

Wm. E. Fyfe & Co., Clinton, Mass.: —
  Canada Unleached Hard-wood Ashes.

R. & J. Farquhar & Co., Boston, Mass.: —
  Clay's London Fertilizer.

Thomas Hersom & Co., New Bedford, Mass.: —
  Meat and Bone.
  Bone Meal.

F. E. Hancock, Walkerton, Ontario, Can.: —
  Pure Unleached Hard-wood Ashes.

The Hardy Packing Co., Chicago, Ill.: —
  Hardy's Tankage, Bone and Potash.
  Hardy's Tobacco and Potato Special.
  Hardy's Complete Manure.

C. W. Hastings, Cambridgeport, Mass.: —
  Ferti Flora.

John Joynt, Lucknow, Can.: —
  Pure Canada Unleached Hard-wood Ashes.

Thomas Kirley & Co.'s Fertilizer Works, South Hadley Falls, Mass.: —
  Pride of the Valley.

Lister's Agricultural Chemical Works, Newark, N. J.: —
  Lister's Success Fertilizer.
  Lister's Special Corn and Potato Fertilizer.
  Lister's High-grade Special for Spring Crops.
  Lister's Animal Bone and Potash.

Lowell Fertilizer Co., Boston, Mass.: —
  Swift's Lowell Bone Fertilizer.
  Swift's Lowell Potato Phosphate.
  Swift's Lowell Market Garden.
  Swift's Lowell Tobacco Manure.
  Swift's Lowell Potato Manure.
  Swift's Lowell Animal Brand.
  Swift's Lowell Fruit and Vine.
  Swift's Lowell Dissolved Bone and Potash.
  Swift's Lowell Ground Bone.
  Nitrate of Soda.
  Muriate of Potash.
  Swift's Lowell Lawn Dressing.
  Acid Phosphate.

McQuade Bros., West Auburn, Mass.: —
  Ground Bone.

Geo. L. Munroe, Oswego, N. Y.: —
  Pure Canada Unleached Hard-wood Ashes.

Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
  Potato Manure.
  Tobacco Starter improved.
  Tobacco Manure Wrapper Brand.
  Fruit and Vine Manure.
  Economical Potato Manure.
  Average Soil Complete Manure.
  Vegetable Manure or Complete Manure for Light Soils.
  Corn Manure.
  Complete Manure "A" Brand.
  Cereal Brand.
  Complete Manure Ten Per Cent. Potash.
  Complete Manure for General Use.

Mapes Formula and Peruvian Guano Co. — *Con.*
- Cauliflower and Cabbage Manure.
- Lawn Top-dressing.
- Grass and Grain Spring Top-dressing.
- Top-dressing improved, One-half Strength.

National Fertilizer Co., Bridgeport, Conn.: —
- Chittenden's Complete Fertilizer.
- Chittenden's Market Garden.
- Chittenden's Potato Phosphate.
- Chittenden's Fish and Potash.
- Chittenden's Ammoniated Bone.
- Chittenden's Universal Phosphate.

New Bedford Product Co., New Bedford, Mass.: —
- Tankage.

New England Fertilizer Co., Boston, Mass.: —
- Corn Phosphate.
- Potato Fertilizer.
- Seeding-down Fertilizer.

Olds & Whipple, Hartford, Conn.: —
- Complete Tobacco Fertilizer.
- Vegetable Potash.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
- Plymouth Rock Brand.
- Special Potato.
- Star Brand.
- P. & P. Potato.
- A. A. Brand.
- Pure Ground Bone.
- Nitrate of Soda.
- Muriate of Potash.

Benjamin Randall, Boston, Mass.: —
- Market Garden.
- Farm and Field.

Rogers & Hubbard Co., Middletown, Conn.: —
- Hubbard's Pure Raw Knuckle Bone Flour.
- Hubbard's Strictly Pure Fine Bone.
- Hubbard's Oats and Top-dressing.
- Hubbard's Soluble Potato Manure.
- Hubbard's Corn and General Crops.
- Hubbard's Soluble Tobacco Manure.
- Hubbard's Grass and Grain Fertilizer.
- Hubbard's All Soils and All Crops Fertilizer.
- Hubbard's Potato Phosphate.
- Hubbard's Corn Phosphate.
- Hubbard's '02 Top-dressing Phosphate.

Rogers Manufacturing Co., Rockfall, Conn.: —
- All Round Fertilizer.
- Complete Potato and Vegetable.
- Complete Corn and Onion.
- Complete Fish and Potash.
- High-grade Grass and Grain.
- High-grade Tobacco and Potato.
- High-grade Oats and Top-dressing.
- High-grade Soluble Tobacco.
- Pure Fine Ground Bone.

Russia Cement Co., Gloucester, Mass.: —
- Essex Dry Ground Fish.
- Essex Complete Manure for Potatoes, Roots and Vegetables.
- Essex Complete Manure for Corn, Grain and Grass.
- Essex Market Garden and Potato Manure.
- Essex A. L. Superphosphate.
- Essex X. X. X. Fish and Potash.
- Essex Odorless Lawn Dressing.
- Essex Special Tobacco Manure.
- Essex Tobacco Starter.
- Essex Corn Fertilizer.

Chas. Stevens, Napanee, Ontario, Can.: —
- Beaver Brand Ashes.

Salisbury Cutlery Handle Co., Salisbury, Conn.: —
- Fine Bone.

Sanderson's Fertilizer and Chemical Co., New Haven, Conn.: —
- Sanderson's Old Reliable.
- Sanderson's Formula A.
- Sanderson's Formula B.
- Sulfate of Potash.

Thomas L. Stetson, Randolph, Mass.: —
- Bone Meal.

J. Stroup Son & Co., Boston, Mass.: —
- Canada Hard-wood Unleached Wood Ashes.

Jas. P. Trainor, Jamesville, Mass.: —
- Pure Ground Bone.

Darius Whithed, Lowell, Mass.: —
- Champion Animal Fertilizer.
- Flour of Bone.

The Whitman & Pratt Rendering Co., Lowell, Mass.: —
- Whitman & Pratt's Potato Plowman.
- Whitman & Pratt's Corn Success.
- Whitman & Pratt's Pure Ground Bone.

Wilcox Fertilizer Works, Mystic, Conn.: —
- Complete Bone Superphosphate.
- Potato Manure.
- Fish and Potash.
- High-grade Tobacco Fertilizer.
- Dry Ground Fish.

Sanford Winter, Brockton, Mass.: —
- Pure Fine-ground Bone.

J. M. Woodard & Bro., Greenfield, Mass.: —
- Tankage.

PART II. — REPORT ON GENERAL WORK IN THE CHEMICAL LABORATORY.

CHARLES A. GOESSMANN.

1. Analysis of materials sent on for examination.
2. Notes on wood ashes.

1. ANALYSIS OF MATERIALS SENT ON FOR EXAMINATION.

During the season of 1902, 217 samples of fertilizing materials, soils, etc., have been received from farmers within our State. The results of analysis of these substances have been published, when deemed of importance to the general public, in three bulletins: No. 81, March; No. 83, July; and No. 84, November, 1902, of the Hatch Experiment Station of the Massachusetts Agricultural College.

Nearly every manufacturing industry has its by-products, which have often a distinct value for manurial purposes. The use of this class of materials has been encouraged whenever the chemical analysis of the same proves them to be of sufficient value to merit their use. The investigation of general fertilizing material of this nature is carried on free of charge to farmers in the State; the material is taken up for analysis in the order of arrival of samples at this office. We have advised farmers to send material for free analysis as early in the season as possible, as work of this nature has to be suspended during the rush of official inspection work during the spring and summer months. Following is a list of materials received during the past season: —

Wood ashes, ...	52	Dry ground fish, . . .	10
Miscellaneous material, . .	25	Ground bones, . . .	6
Soils, ...	35	Onions, ...	8
Complete fertilizers, . .	22	Natural phosphates, . .	6

Cotton-seed meal,	4	Castor pomace,	1
Horn dust,	3	Sulfate of potash,	1
Mill waste,	2	Hemp ashes,	1
Wool waste,	3	Air-slaked lime,	1
Sheep manure,	2	Nitre lime,	1
Tankage,	2	Nitrate of soda,	1
Barnyard manure,	2	Low-grade sulfate of potash,	1
Acid phosphate,	2	Dissolved bone-black,	1
Carbonate of potash,	2	Muriate of potash,	1
Lime ashes,	2	Sulfate of ammonia,	1
Paris green,	1	Mold from compost pile,	1
Basic slag,	1	Waste ashes,	1
Pulverized rock weed,	1	Burned bone,	1
Coral formation,	1	Turf,	1
Leaf mold,	1	Tan-bark ashes,	1
Peat,	1	Brick-yard ashes,	1
Vegetable potash,	1	Sizing paste,	1
Tobacco stalks,	1	Sewage,	1
Cotton-hull ashes,	1	Acetylene tank refuse,	1
Celery plant,	1		

As in the past, we have collected and analyzed samples of Paris green and other insecticides found in our general markets. The analysis of these materials will be found in our March bulletin, No. 81, for 1902.

We have been engaged in work for the Association of Official Agricultural Chemists, to assist in the selection of the best methods of analysis of insecticides, etc., and have taken up co-operation work for the association on new methods of potash determination. The results of this work do not appear in our publications, the work being of technical nature, and of value only to the Association of Official Agricultural Chemists in the establishment of new methods of analysis.

We are constantly occupied with investigations of new methods for the determination of the available plant food in soils, and new and improved methods for the ash analysis of plants, and have been to considerable expense in procuring the equipment for the latter work, being obliged to import most of the apparatus from Germany. The equipment consists of a power mill (*Kugelmuhle*) to be used in the preparation of the plant for analysis, and which eliminates all danger of the contamination of the sample with iron or other metallic substances, the grinding being accomplished by means of porcelain balls revolving within a tightly sealed porcelain vessel. In this connection we have imported suitable platinum apparatus, recommended by Wislicenus, Tollens and others, for the purpose of securing the ashes of plants at a low temperature; its structure being such as to eliminate all danger of the volatilization of potash, soda, phosphoric acid and other mineral constituents of plants. Attention has also been directed to the investigation of the available phosphoric acid in natural phosphates. The results of investigations above mentioned will be published from time to time, whenever the results prove of general interest and value to the public.

2. Notes on Wood Ashes.

During the season of 1902, 24 per cent. of the materials forwarded for analysis consisted of wood ashes. The following table shows their general chemical character: —

Analysis of Wood Ashes.	Number of Samples.
Moisture below 1 per cent.,	2
Moisture from 1 to 10 per cent.,	18
Moisture from 10 to 20 per cent.,	22
Moisture from 20 to 30 per cent.,	6
Potassium oxide from 7 to 8 per cent.,	4
Potassium oxide from 6 to 7 per cent.,	8
Potassium oxide from 5 to 6 per cent.,	21
Potassium oxide from 4 to 5 per cent.,	12
Potassium oxide from 3 to 4 per cent.,	2
Potassium oxide below 3 per cent.,	1
Phosphoric acid from 1 to 2 per cent.,	46
Phosphoric acid below 1 per cent.,	2
Average per cent. of calcium oxide (lime),	32.18
Insoluble matter below 10 per cent.,	15
Insoluble matter between 10 and 15 per cent.,	17
Insoluble matter between 15 and 20 per cent.,	13
Insoluble matter above 20 per cent.,	3

The average standard of this class of materials remains about the same as in previous years.

Farmers have been advised to patronize dealers and importers of wood ashes who are on record at our institution as having complied with our State laws and secured licenses for the sale of their article in Massachusetts, for only in such cases is a protection by our State laws possible. We have also urged them to state in every case the particular source from which the materials forwarded for free analysis have been derived.

REPORT OF THE HORTICULTURIST.

F. A. WAUGH.

During the year the work of the division of horticulture has been extensively reorganized. These changes have been necessitated partly by new conditions and partly by a change in the administration of the division. The principal innovations are three, as follows: —

1. The abandonment of miscellaneous variety tests, and the substitution, in their place, of systematic studies of varieties from all sources and under all conditions.

2. The establishment of definite lines of experiment designed to develop the principles underlying the practice of fruit and vegetable culture.

3. The opening of an extensive system of permanent records, which are expected to hold together the work of successive years, to assist in the interpretation of current observations by offering a comparison with previous results, to make possible the accumulation of comparable data through a period of years, to make the results of experiments at all times available, and, in general, to secure definiteness of aim, clearness of interpretation and consectivity of work in all the experimental operations of the division.

There is no need of publishing at this time a full programme of the experimental work already determined on. It may be proper to say, however, that the work is planned to cover certain important practical problems in the propagation and cultivation of orchard fruits, particularly apples, peaches and plums, and similar investigations in the culture of small fruits and vegetables.

As has been the practice hitherto, every effort will be made to furnish prompt and reliable information in response to the many inquiries which are sent in from day to day.

REPORT OF THE BOTANISTS.

GEORGE E. STONE, RALPH E. SMITH.

Plant Diseases in 1902.

Diseases affecting cultivated plants have, as usual, caused more or less damage during the past season. The following pages describe briefly the occurrence of the most important.

Peach-leaf Curl (*Exoascus deformans*).

This fungus was rather more prevalent than usual early in the season. Its effects were most noticeable upon young trees, particularly upon Elberta and Crosby, these varieties being attacked to the exclusion of others in the same orchards. Though very destructive in many portions of the country, it is not commonly a serious one in Massachusetts.

Apple-leaf Spot.

One of the most noticeable troubles of the season has been the injury to apple foliage caused by frost, which is described elsewhere in this report. Many trees, after the spotting and yellowing of the leaves early in the season, were quite denuded by midsummer. Well-cared-for trees were not often affected, so that the actual damage from this source was probably very slight.

Sycamore Blight (*Glœosporium nervisequum*).

This disease was, as usual, very severe, causing the fall of almost all the leaves on sycamore trees during June and July.

Strawberry Root Rot.

This apparently new trouble of the strawberry plant (see p. 34) was much complained of in new beds set out this season.

Apple Scab (*Fusicladium dendriticum*).

Both early and late apples were badly affected by scab during the year, except on high ground.

Cucumber Wilt.

This bacterial disease was more prevalent than ever before in large cucumber fields, and is evidently on the increase, though no great damage resulted this year.

Sweet Pea Troubles.

The cool, moist summer proved very favorable to the growth of this plant, and much less trouble than for several years was experienced by large growers. The "shelling" of the buds and blossoms, brought on by close, muggy weather, occurred somewhat; but the blight of the vines, so common and destructive of late, appeared very little this season.

Aster Diseases.

The "yellow" disease of this plant was noticeably less abundant than usual this year, its prevalence being evidently influenced by the character of the season. The wilt or stem rot proved very destructive in many plants started in the greenhouse, while those grown entirely out of doors were comparatively free from its attack.

Potato Blight (*Phytophthora infestans*).

This disease came on somewhat later than usual, being retarded by cool weather early in August. It soon became prevalent, however, and rotting of the tubers was unusually severe, the crop being greatly diminished.

Cucumber and Melon Diseases.

These plants suffered greatly during the season from a variety of causes, chief among which was the downy mildew (*Plasmopara cubensis*), the unusual prevalence of which is described more fully elsewhere in this report. The *Alternaria* disease and anthracnose were also common. Muskmelons were a total failure everywhere, and cucumbers were considerably injured. The cold, wet season proved very unfavorable to the melon crop, so that the vines readily succumbed to disease.

Asparagus Rust (*Puccinia Asparagi*).

Asparagus plants were affected by rust much less than in previous years, demonstrating the influence of conditions of weather upon this disease.

Chrysanthemum Rust (*Puccinia Hieracii*).

The destructiveness of this disease, which has seriously threatened the chrysanthemum, is evidently declining. Cases of its occurrence have been very few this season, and no serious damage has been evident.

The Cucumber Mildew in Massachusetts (*Plasmopara Cubensis* (B. & C.) Humph.).

The general occurrence of this disease during the past season upon cucumbers and melons calls attention to its peculiar history in this State. The fungus was described from Cuba many years ago, but was discovered in this country in 1889, when it appeared in Massachusetts, New Jersey and other States at about the same time. In the report of the Massachusetts Experiment Station for 1889, Dr. Humphrey, then of this division, noted the occurrence of the disease, calling attention to the serious damage which its general distribution might cause. In subsequent years this mildew became very prevalent throughout the southern and middle States, causing great damage each year to cucumbers and melons as far north as Long Island, but not in New England. From this limited distribution it appeared that the fungus required a somewhat warmer climate than ours for its normal development.

In the autumn of 1900 the downy mildew appeared again in this State, being found upon greenhouse cucumbers in two different localities, as noted in the report of this division for that year. These were the only cases known at that time. The next season the muskmelon crop all over the State was quite generally affected and destroyed by this fungus, which also occurred abundantly upon greenhouse cucumbers, but was not observed upon the latter plant when grown out of doors. During the past season (1902) muskmelons have been almost a total failure from this cause; and cucumbers, both in and out of doors, have been generally affected, the fungus being abundant everywhere upon these two plants.

Thus it appears that for the past three years this fungus has been steadily increasing in its distribution. Its most serious effects in this State have been upon the muskmelon. Scarcely a single melon was obtained this year by most of the growers, the vines being killed completely within a few days' time. Experiments in spraying, made in co-operation with this division in several different places, have shown but little gain. It seems quite evident, in fact, that so long as this disease continues to prevail the muskmelon cannot be grown in Massachusetts. The plant is not naturally adapted to our climate, and succeeds at best only in favored localities. When attacked by disease it succumbs very easily, especially in such an unfavorable season as the past one has been.

Upon the cucumber, the disease, while general, is as yet by no means as serious. Out-of-door fields showed the fungus everywhere this year, but the vines remained alive for some time, and the yield did not appear to be seriously diminished. This, however, is but one year's experience.

The effect of this disease upon greenhouse cucumbers is perhaps the most important consideration of the whole subject. Here is an industry of considerable and very rapidly increasing importance in this State, involving, relative to most other agricultural industries, a large amount of capital. It is one in which success means good profits and failure large losses. No serious obstacle which cannot be overcome has as yet been met with, but considerable alarm has been caused by the general appearance of the downy mildew. It may be said, however, that thus far no great damage has been evident. It is noticeable that the disease is most serious in the greenhouse upon plants started in August, which is the time of its occurrence out of doors. Those started later in the season or in spring do not seem to suffer. Even when present in the house, the disease does not kill the vines outright, and by picking off the affected leaves growers have succeeded in keeping it considerably in check. It is therefore recommended that greenhouse cucumbers be started as late as possible, to avoid the mildew. Plants started in October have not shown the disease, where those planted in August were badly affected. This is the safest and easiest preventive. In case this is impracticable, on account of an early crop being desired, a dry atmosphere in the house will largely prevent the spread of the mildew, the development of which is favored by atmospheric moisture. By removing affected leaves, and keeping the house dry, the disease can be effectually kept down. A third remedy lies in spraying, which must be resorted to with an early crop in moist atmosphere. This has been practised very successfully with out-of-door cucumbers upon Long Island, using the Bordeaux mixture. Spraying can be done thoroughly in the greenhouse, and both sides of the leaves should be well covered.

The Muskmelon Blight.

On account of the general prevalence and general destructiveness of this disease, melon growing has become practically impossible in Massachusetts. This plant, as described in our last report, has become affected worse and worse each year with several different fungous diseases, the attacks of which its delicate nature has little power to resist. The chief trouble this year and last has been the downy mildew, in connection with which the anthracnose and *Alternaria* disease have also developed. The cold weather of the last season was very unfavorable for muskmelons, making it almost impossible to get vigorous plants started. Those started in-doors and transplanted made practically no growth for weeks after being set out, and fell an easy prey to disease. The *Alternaria* disease appeared about July 15, but appeared to cause no immediate damage; but the mildew, coming on in the latter part of August, killed the vines completely all over the State, and no returns whatever were received from many large fields. After these two years of complete failure since the mildew appeared, it is probable that but few attempts will be made in the near future to grow this crop.

The subject of spraying as a preventive for this trouble has received considerable attention from this division for several years. During the past season experiments were made in co-operation with a local grower along the lines which previous experience had suggested. The details of this work will be reserved for a bulletin ; but it may be said here that, even where plants were thoroughly sprayed with Bordeaux mixture, commencing early in July when the first leaves developed, no effect could be seen upon the development of the mildew. Sprayed and unsprayed plots and fields were alike a complete failure. It therefore seems quite evident that, so long as this disease continues to prevail, the muskmelon cannot be grown here under ordinary treatment. In seasons favorable to the plant, persistent spraying with good culture may give some returns ; but in a poor year the crop is almost sure to be a failure, in spite of anything which can be done to save it. The plant is too poorly adapted to our climate to withstand a serious disease.

An Apple-leaf Spot.

One of the most frequent subjects of inquiry of this division during the past summer was a spotting and dying of apple leaves, which occurred very generally in this and other States. The trouble was first noted in May or early June, when trees affected showed a spotting of the leaves resembling a fungous leaf spot. This occurred quite generally, but usually on trees in pastures and by roadsides, rather than in well-kept orchards. The spotting was also more evident on low, frosty ground. With the advance of the season the spotting became much more marked, the foliage gradually turning yellow and dropping from the trees. This became very noticeable and caused considerable alarm, being in striking contrast to the usual healthy condition of apple foliage. Good orchard trees were in few cases seriously affected, though in some the spotting came on rather late in the season. The trouble prevailed mostly in neglected trees growing under unfavorable conditions ; most of these lost their leaves during the summer.

Investigation of affected leaves failed at all times to show any fungus or other organism which could be regarded as the cause of the spotting, but revealed peculiarities which point to a cause of quite a different nature; namely, the occurrence of freezing temperature and frost at the time the leaves were unfolding, and subsequent cold, wet weather to an unusual extent throughout the season. At the time when apple trees were leaving out, a period of very low temperature came on, with frost and ice. Immediately following this the first spotting of the leaves appeared, being most noticeable in the most frosty places. Affected leaves showed numerous dead spots, especially near the veins, where would be the largest amount of water. In these spots the tissue was dead and ruptured. No organism was to be found as the cause of the injury, and from the sequence of events there could be no reasonable doubt that the frost was the destructive agency. As the season progressed, these leaves gradually dropped off, as might be expected. Further than this, however, the spotting of the leaves gradually increased through the summer, so that in the latter part of the season trees were affected which had not shown the trouble at first, while those originally affected lost almost all their leaves. This at first sight seemed to render it impossible that the trouble was due to the spring frost, since much of the spotting did not appear until August, particularly in well-cared-for orchards. In all these cases, however, the injurious effects were undoubtedly due to the same original cause. Careful microscopic examination of leaves when first affected showed not only the actual dead spots, but also many other portions affected in a peculiar manner. Here and there on the leaf could be found minute, blister-like spots, retaining at first the natural green color. In these places freezing had evidently occurred, causing more or less mechanical injury to the tissues, but not sufficient to cause immediate death. The epidermis became separated from the underlying cells, and more or less ruptured. In such spots, apparently, originated the trouble manifested later in the summer. The weather, being abnormally wet and cold, produced a low state of vitality, so that the tissue gradually died away in these injured places, and visible dead spots appeared. Orchard trees in good condition were perhaps less affected in the first place, and subsequently were better able to withstand the injury, owing to their better condition. This trouble is an unusual one, of more interest on account of its peculiar nature than from any economic importance.

A Strawberry Disease.

Many complaints were made during the past summer of the dying of strawberry plants set out in new beds. The same also occurred to a much less extent in old beds at the time of fruiting. In the latter case the trouble appeared as a withering and dying of the fruit stalks, followed by the same effect in the leaves. Much more pronounced was the case of the new beds, where in numerous instances many of the young plants withered away in July, showing symptoms of a very definite nature. The first indications of the disease appeared in the leaf stalks, which showed a dark discoloration and withering. Following this the leaves slowly faded away, the whole plant finally becoming dead. The trouble at first sight appeared to be located in the petioles, where the black spots first appeared. Examination of these parts, however, showed no fungus present, nor anything which would account for the effect. The roots of affected plants were found in all cases to be in very poor condition, the older ones being decayed and little new growth present, as should be the case where the plants had been set out some time. Further examination showed that a fungous growth was present in almost all the roots of affected plants, apparently causing them to rot away at the ends. Even in the sound parts this fungus could be detected, growing in from the outside toward the centre. In affected plants from many different localities the same condition was found, so that there can be little doubt that the withering of the petioles and leaves was due to the rotting of the roots. Attempts were made to obtain cultures of the fungus, in order to determine its identity more definitely and test its effect upon healthy plants. As this was not accomplished, no definite conclusions can be drawn as to the actual cause of the disease. The cold, wet weather of the past season would naturally tend to aggravate a trouble of this nature, but its general and characteristic occurrence indicates the presence of a more definite cause than this. Should the disease continue to prevail, care should be taken in starting new beds to propagate only from healthy, vigorous plants.

Plum "Yellows."

A disease apparently similar to the "yellows" of the peach has been noticed for several years upon the college grounds. It occurs only upon the Japanese varieties, particularly the Abundance, and is as yet of no serious consequence. The trouble is characterized by the production of wiry yellow shoots, just as in the peach yellows.

SPRAYING OF LINDEN AND ELM TREES FOR LEAF SPOT.

Both of these shade trees are frequently affected with leaf-spot fungi, which sometimes becomes quite abundant, causing the leaves to fall prematurely. Some lindens on the college grounds become badly affected each year with leaf spot (*Cercospora microsora*), while other much younger trees show little or no trace of it. The older, infected trees are also more or less injured by borers, and many of the younger trees show the effects of sun scald on their trunks. The presence of the leaf spots on the older trees in such abundance is probably secondary, *i.e.*, the trees are in such poor condition they induce leaf spot to thrive. Elms are not so badly affected with the leaf spot (*Dothidella ulmea*) as lindens with the *Cercospora*. Some lindens and elms were sprayed twice this summer, viz., July 12 and August 13. The result of this spraying was very marked. The sprayed linden trees could be easily identified by any one during September and October, on account of the more abundant foliage and greener color of the leaves. The foliage remained on the sprayed trees some days longer than on the unsprayed ones. While the sprayed trees were affected to some extent with the spot fungus, there was a decided difference in the amount of infection between the treated and untreated. Better results would undoubtedly have been obtained if the lindens had been sprayed earlier, or about July 1, as at the time of the first spraying the spot was beginning to appear.

None of the elm trees, either the sprayed or unsprayed, developed much of the leaf spot. All that can be said in favor of the sprayed trees is that their foliage remained green longer than the other trees, and the trees retained their leaves the latest of any. We estimate that linden trees affected as these were, if sprayed twice during the season, would result in a gain of from two to five per cent. in their growth and development. The cost of spraying was insignificant, as the trees were not large. The question involved in all such instances is, whether the tree is worth the expense. This depends on the owner's interest in such matters, and in the means and facilities to have such work done.

CROPS UNDER TENT CLOTH.

Much interest has been manifested in Massachusetts and Connecticut in the last two or three years in growing Sumatra tobacco under tent cloth. That the environmental conditions of plants are greatly modified under tent cloth is well known. Besides exerting a characteristic influence on the texture of the plants, we might expect, from our knowledge of the conditions which favor fungous infection, that the conditions prevailing under tent-cloth culture would result in producing in certain cases beneficial results. In some instances tobacco growers have planted cucumbers, watermelons, tomatoes, etc., on the border of tobacco beds planted under tent cloth, largely as a matter of curiosity, to see how they would develop under these conditions. So far as the production of fruit is concerned, it may be stated that these experiments have been a failure, because no adequate provision was made to fertilize the flowers. As a result of this, plenty of fruit set but did not mature. The foliage of watermelons which was observed under tent cloth was in excellent condition. We noticed, however, on a few vines about a dozen leaves affected with *Alternaria*, which, however, showed no tendency to spread. Muskmelons developed good vines and foliage, but towards the latter part of the season they showed some of the usual blights. The foliage of tomato plants which we observed was absolutely perfect, there being no trace of the flea beetle or *Macrosporium*. None of the crops developed any fruit of any consequence. The melons, etc., should have been provided with bees to fertilize the flowers, and the tomatoes should have been shaken frequently, to accomplish the same purpose. Cucumbers did well, but failed on account of bees to set fruit. It is generally agreed by growers that the foliage produced under tent cloth was of superior quality, though, on account of the inability of the crops to set fruit, they were considered a failure. The foliage of geraniums and other decorative plants was excellent, and the geraniums showed no tendency to a leaf spot which had been rather abundant during the past summer. Our experiments in growing muskmelons under glass during the summer were more favorable than those conducted under tent cloth, both in respect to fungi and setting fruit. Our melon crop ran into October, and there was not to be seen the slightest trace of any form of blight during the whole season. The house was ventilated freely during the day time, hence allowing insects free opportunity to fertilize the flowers, as a result of which we had a superabundance of fruit. Since it was our purpose to observe what effect the absence of moisture would have upon infection, the foliage of the vines was kept entirely free from water throughout. Notwithstanding that the various blights which affect the cucumber were present everywhere out of doors, no infection took place in this crop. We are convinced that *Plasmopara* or the downy mildew (see p. 31) can be held in check in greenhouses, if the moisture conditions are controlled; and the same may hold good to some extent in the *Alternaria* and the anthracnose. At any rate, none of these fungi made their appearance on the foliage under glass. There is considerable difference in the conditions prevailing under glass from those under tent cloth. Tent cloth may succeed in keeping off dews and mists from the plants. It will, however, allow rain to pour through without much difficulty, whereas the greenhouse can be kept practically tight. In conclusion, it may be stated that it is not generally conceded by tobacco growers who experimented with cucumbers, etc., under tent cloth, that this method of culture will be of any practical importance in the cultivation of garden crops. It is quite evident, however, that it succeeds in producing plants of better foliage, and, on the whole, it has a value in certain cases of preventing infection.

Experiments in Heating Soils.

The rather unusual interest taken in the problem of soil sterilization within the last few years has been the means of inducing growers to improvise various devices for heating soil. Some of these appliances have been constructed for personal use only, while others have been patented and placed on the market. The diameter of the tubing and method of perforating, together with the size and number of the perforations, differ much in the various appliances. The amount and pressure of steam and distance between pipes in the soil also vary with different appliances, as does the relative efficiency and cost of heating. Our experiments, which were rather limited in extent, consisted in testing the relative heating capacity of pipes one foot long and of various diameters, which contained the same number and area of perforations ; also of pipes of the same diameter, containing various sizes and numbers of perforations. We made use of iron pipe, galvanized iron and tin tubing, and porous tile. In order to test their relative efficiency, we placed them in the centre of a keg that had a hole bored in the side for a thermometer, which in each case was placed about six inches from the tubes. The keg was filled with soil, and steam entered into the tube. All of the tubes except the tile were plugged at the lower end, and the steam had to penetrate the soil through the perforations. The table shows the result of these experiments : —

Table showing the Relative Heating Efficiency of Tubes of Various Diameters, Sizes, and Numbers of Perforations.

KIND OF TUBE.	Number of Perforations.	Area of Perforations (Square Inches).	Size of Perforations (Inches).	Time required to heat Soil 200 Degrees F. (Minutes).
(*a*) Two-inch iron pipe, . .	44	1.21	3/16	5
(*b*) One-inch iron pipe, . .	44	1.21	3/16	11
(*c*) Two-inch colander tin, .	4,646	14.26	1/16	2½
(*d*) Two-inch galvanized iron,	29	1.42	¼	2
(*e*) Two-inch galvanized iron,	116	1.42	⅛	3¼
(*f*) Two-inch tile, . . .	–	–	–	7½

A comparison of one-inch and two-inch iron pipes, each containing four rows, giving a total of forty-four perforations, three sixteenths of an inch in diameter, gave as a heating capacity for two-inch pipe five minutes, and for one-inch pipe eleven minutes; or, in other words, it requires six minutes longer for the one-inch pipe to heat the same mass of soil than the two-inch pipe. An average of four experiments gave for the two-inch pipe nine minutes and for the one-inch pipe seventeen minutes, or nearly the same ratio.

Two tests were made with one and one-half inch pipe, similar in every way to those just described. Since this pipe was mislaid, further experiments with it were discarded. It may be stated, however, that the results obtained by the use of this pipe were better than those with the one-inch, although not so good as those obtained by the use of the two-inch.

A comparison of the three perforated tin and galvanized iron tubes (*c*, *d* and *e*) showed little variation in heating capacity. The colander tin tubes, however, had a great many perforations, representing a much larger area for steam to escape. Notwithstanding this, it was not superior to tube *d*, which was a section of Cartter's sterilizing apparatus. The experiment with tile (*f*) was, as might have been expected, less satisfactory as a heater than any of the others except the one-inch pipe. The lower end of the tile was not closed, hence practically all the heat which escaped did so through both ends of the tile, and only a little through the pores.

In these experiments it appears that a two-inch pipe is far superior to a one-inch pipe as a heater, where the number and size of the perforations are the same; also that for all practical purposes one-fourth-inch perforations are better than smaller ones, even where the total area is the same or even greater. It is therefore not so desirable, if efficiency is to be considered, to construct sterilizers out of one-inch iron pipe, as some have done, inasmuch as a two-inch tubing with three-sixteenths or one-fourth inch perforations will give better results. The best results were obtained with a section of Cartter's tube, which contained four rows of perforations one-fourth inch in diameter.

In heating soils there are many factors which have to be taken into consideration, such as the pressure and the amount of steam supplied, the size of the apparatus, and the amount of earth that is to be heated. These factors are so variable that probably no two men have sterilized soil at the same cost. Sterilizers that will do rapid and cheap work at a certain pressure and supply of steam will do less work at a greater cost with the same pressure and less volume of steam. It is not only essential that the sterilizer should be constructed on the best principles, but the volume of steam and pressure maintained should be adapted to the requirements.

Influence of Sterilized Soil on Seed Germination.

In previous reports and bulletins from this station there have been given results of some experiments relating to the influence of various agencies upon the germination of seeds. For some years much use has been made of sterilized soils by this division in studying the various diseases of greenhouse crops. In numerous experiments, made upon a considerably large variety of plants, we have always noticed the marked effect which sterilization had upon the germination of seeds and the subsequent growth of the plant. Many photographs have been made from time to time of those crops which display very important differences, and in some instances the weight of the plants has been recorded, which show the marked effects that soil sterilization has upon germination and growth. We had made no experiments, however, to ascertain to what extent acceleration took place in seed germination, until the following were made, the results of which are shown in the table : —

Germination of Seeds in Sterilized and Unsterilized Soil.

NUMBER OF EXPERIMENT.	Kind of Seed.	Total Number of Seed tested.	NUMBER GERMINATED IN —		Per Cent. Gain or Loss.
			Sterilized Soil.	Unsterilized Soil.	
Experiment 2, .	Radish, ...	600	159	81	41
Experiment 3, .	Tomato, ...	600	93	110	—13
Experiment 5, .	Cucumber, . . .	600	281	187	33
Experiment 10, .	Lettuce, ...	600	26	10	61
Experiment 11, .	Tomato, ...	600	37	33	10
Experiment 13, .	Onion, ...	400	48	31	35
Experiment 14, .	Mustard, . . .	400	84	32	61
Experiment 15, .	Turnip, ...	400	105	37	64
Experiment 16, .	Red clover, . . .	400	68	45	33
Experiment 17, .	Onion, ...	200	57	32	43
Experiment 18, .	Red clover, . . .	200	83	73	12
Experiment 21, .	Lettuce, ...	200	87	26	70

In these experiments we purposely made use of seeds representing considerable variations in age and of low germinating capacity, and where certain numbers are omitted in column 1, it should be understood that in such cases the seeds were so old that little or no germination took place. The seeds in each experiment were taken from uniform lots, *i.e.*, they were supposed to be of the same age and from the same source ; and where the same kind of seed appears twice in the table, it indicates that they are of different age and origin. Two hundred seeds were used in each experiment, one hundred being sown in sterilized soil and one hundred from the same lot in unsterilized soil. In some instances the experiment is repeated three times, in which case we have the average germination of six hundred seeds. The soil used was the same, except that one lot was sterilized, the other not. The lower the per cent. of germination which seeds exhibit, the more important it is that a larger number should be employed in order to obtain true averages. Where seed showed 95 per cent. germinating capacity, a test including one hundred seeds is of some value. On the other hand, where there is only a germination equal to 10 per cent., a truer average can be obtained by employing eight hundred or a thousand or more, or, what is better, to repeat the experiment at least half a dozen times with a smaller number of seeds. The high percentages given are somewhat misleading, as the number of seeds used was not sufficient to obtain reliable averages. All of the experiments could be repeated to advantage. Since in many instances the seeds were used up, it was not possible to continue the experiments further. These experiments, nevertheless, possess a certain value, and the results coincide in a general way with what we have continually observed in the greenhouse. In germinating thousands of lettuce seeds in boxes we have noticed many instances similar to that shown on No. 21, although the percentage of gain is too high for average results. The average acceleration given in all of the experiments shown in the table, or the percentage of germination noted on the fourth day after planting, was 25 per cent. in favor of the sterilized soil. It will be noticed that the tomato seeds do not respond to sterilized soil, and in four out of seven tests those growing on unsterilized soil gave the best results. Since these experiments are preliminary ones, and are being continued, further comments at this time are not necessary, except to relate that from an economic point of view we consider it worth while to start such plants as lettuce, cucumbers, melons, tobacco, etc., in sterilized soil, provided steam is available. In such cases the expense would be very insignificant. Besides returns from acceleration and increase in germinating capacity, the important factor of immunity from diseases such as those arising from the damping fungus, etc., is important.

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

The work of the meteorological division of this station during the past year has been much the same as outlined in previous reports. The abnormal temperature conditions prevailing during much of the growing season caused more than the usual interest in the monthly bulletins issued, and in abstracts from them published by a considerable number of the papers of the State.

At the end of June, Miss S. C. Snell, the voluntary observer for the United States Weather Bureau, resigned after a service of more than twenty-five years. At the request of Mr. J. W. Smith, section director, the station has arranged to furnish the temperature and precipitation records on the voluntary observer blanks, in addition to the records published in the monthly bulletin. All records for Amherst now published in the monthly report of the New England section of the climate and service of the Weather Bureau are now credited to the Hatch Experiment Station, instead of only the barometer and wind records, as formerly. Arrangements have been made to furnish the weekly snow reports to the Boston office the present winter, as heretofore.

The local forecasts for the weather of the following day have been furnished daily, except Sunday, as in former years. Their transmission to the college by telegraph has been less satisfactory than formerly, owing to the interference of the electric currents of the local electric railways. If our telegraph line from the Western Union office to the tower could be relocated, so as to avoid this interference, the forecasts could be received more certainly and promptly.

The monthly observations of the declination of the magnetic needle have been made, as indicated in last year's report. The laying of steam pipe to the several buildings during the summer has probably affected the results of the last few months. Pending a more complete report of these results, it may be stated that the mean declination for 1900 was 11° 10′ west; for 1901, 11° 10′ west; and for the present year, 11° 14′ west.

The equipment has remained practically the same during the year. In the near future a number of new clocks for some of the self-recording instruments will be required.

At the close of the college year, in June, Mr. H. L. Bodfish, the observer, retired from the division, and was succeeded by the assistant observer, Mr. S. C. Bacon.

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD, H. T. FERNALD.

During the year 1902 the work of the entomological division has been concentrated along a few but important lines. The correspondence has, as usual, occupied much time, and a large portion has been of a routine nature. This part of the work is of great importance, and it has been the intention to give the most careful attention to every letter received, however common the insect concerned may be, as the greatest amount of assistance is often needed in order to effectively combat the most common forms.

Extensive experiments on the best methods of treatment for the San José scale under New England conditions have been carried on in the college orchard during the year. Over six hundred trees have been treated in different ways, and the results studied by means of repeated inspections during the summer and fall. A discussion of this work and its results thus far is now being prepared for publication as a station bulletin.

Much attention has also been given to the preparation of the early stages of insects for the insectary collection. As in most cases the injuries caused by insects are while the latter are immature, the importance of representing all stages in a collection at once becomes evident. In connection with the additions thus made, an extensive rearrangement of the collection has been begun, the result of which will be to make it more instructive and available for direct study and comparison than ever before. Many records and life histories have also been added to the insectary files.

Work on the card catalogue, referred to in previous reports, has been continued, and the value of the catalogue as a whole is demonstrated by its frequent use each day. From it a bibliographical catalogue of the scale insects of the world has been prepared, and is ready for the printer.

The nursery inspection law, passed by the Legislature of 1902, has removed the work of nursery inspections from the list of duties of the entomological division of the station; but the appointment of the associate entomologist of the station as inspector has enabled him to make the service of the station available to many who were not previously aware of the opportunities it offers for assistance in difficulties they meet, and it has also enabled him to learn more of the entomological problems which need investigation in the State than could possibly have otherwise been the case.

Insects of the Year.

No serious insect outbreaks have been observed during the year, though many kinds have made their presence felt.

The brown-tail moth has continued to spread, and in the more central portion of its distribution has become extremely abundant. So serious is it in some places that city and town authorities have taken up the work of gathering and destroying the tents during the winter months, as a partial method of relief from the sufferings which would otherwise be caused from the irritation on the human skin produced by the hairs of this insect during the following summer months. A bulletin has been prepared on this insect, and published by the State Board of Agriculture.

The gypsy moth has increased in numbers, until in some places it is nearly as abundant as it has ever been. In general, however, it has not as yet made its presence seriously felt, though a year or two more is all that will be necessary for it to fully re-establish itself throughout its original territory.

The San José scale is now present in over one hundred cities and towns, and is rapidly spreading, though fortunately the number of food plants on which it thrives so as to endanger the life of the plant appears to be small. During the fall it was found on California privet, arbor-vitæ and spruce,— food plants not heretofore reported, though whether it can live for any length of time on these remains to be seen.

The elm-leaf beetle has attracted but little attention this year, except in the north-eastern part of the State, where it has appeared in abundance for the first time. Elsewhere it was about as plenty as usual, and was generally treated by the tree wardens and city foresters with considerable success. It has now been established that in the Connecticut valley this insect has but a partial second brood, — so small, in fact, that the injury it causes is almost infinitesimal.

The resplendent shield-bearer (*Aspidisca splendoriferella*) has been abundant, attacking the apple leaves, but appears to have caused but a small loss. The apple-leaf miner (*Tischeria malifoliella*) appeared in abundance in apple leaves in the fall of 1901, and was present in large numbers last spring. Careful studies on this insect show that in Massachusetts it is two-brooded, the adults appearing in early spring and also in July.

Two species of *Aleyrodes* have been doing a great deal of damage in some parts of this State, — one in greenhouses, the other out of doors on strawberries and other plants. These species have long been considered identical with *Aleyrodes vaporariorum* Westw., a common European insect, but the one on strawberries proves to be a new species. Both have been very carefully studied here, and the new one described and published with illustrations in the Canadian "Entomologist," under the name of *Aleyrodes packardi*. The studies on the other species will be published with illustrations as soon as completed.

The life histories of several bugs have also been worked out, and are now in the printer's hands for publication.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.

Assistants: E. B. HOLLAND, P. H. SMITH, J. W. KELLOGG,[1] T. M. CARPENTER.[1]
Inspector of Babcock Machines and Dairy Tester: N. J. HUNTING.
In Charge of Feeding Experiments: ABEL GILBERT.
Stenographer: MABEL SMITH.

PART I. — OUTLINE OF YEAR'S WORK.

- A. Correspondence.
- B. Extent of chemical work.
- C. Character of chemical work.
  - (*a*) Water.
  - (*b*) Dairy products and feed stuffs.
  - (*c*) Chemical investigation.
- D. Cattle feed inspection.
- E. Execution of the dairy law.

PART II. — DAIRY AND FEEDING EXPERIMENTS.

- A. Tests of pure-bred cows.
- B. Tests of fly preventives.
- C. Summer forage crops.
- D. The pentosans.
- E. Digestion experiments with sheep, 1894–1902.

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[1] During the year Messrs. Kellogg and Carpenter severed their connection with this division, to accept more lucrative positions elsewhere, the former going to the Rhode Island and the latter to the Pennsylvania Experiment Station. The loss of these two efficient workers has been seriously felt, and naturally impeded the work of the division.

PART I. — OUTLINE OF YEAR'S WORK.

J. B. LINDSEY.

A. CORRESPONDENCE.

The correspondence of this division was about the same in character and amount as in preceding years. Information is asked on a great variety of subjects. Some questions can be easily answered by reference to bulletins already published, while others require considerable thought and study. The total number of letters sent out during the year has been 1,950.

B. EXTENT OF CHEMICAL WORK.

The work in the chemical laboratory has been similar to that of previous years. The large amount of routine work in connection with the examination of water, milk, cream, butter, feed stuffs and miscellaneous substances leaves little time available for strictly chemical investigation. The amount of chemical work may be better understood by noting the variety and number of substances recorded below.

There have been sent in for examination 181 samples of water, 120 of milk, 1,482 of cream, 118 of pure and process butter, 9 of oleomargarine, 130 of feed stuffs and 9 of miscellaneous substances. In connection with experiments by this and other divisions of the station, there have been analyzed, in whole or in part, 187 samples of milk and cream, 42 of butter fat and 642 of fodders and feed stuffs. There have also been collected, under the provision of the feed law, and tested, either individually or in composite, 320 samples of concentrated feed stuffs. This makes a total of 3,240 substances analyzed during the year, as against 3,622 last year and 3,036 in the previous year. Work on pentosans, fiber, starch, sugar and fat, and on the availability of organic nitrogen, not included in the above, has been done for the Association of Official Agricultural Chemists. In addition, 13 candidates have been examined and given certificates to operate Babcock machines in creameries and milk depots, and 2,344 pieces of glassware have been tested for accuracy.

C. CHARACTER OF CHEMICAL WORK.

(*a*) *Water.*

This division during the past year has endeavored to make sanitary analyses of drinking water, so far as time and means would permit. Samples were received not only from farmers, but from persons following various trades and professions. They were practically all from wells, springs and ponds, in towns not provided with a public water supply. A few were of excellent quality, many of fair quality only, others quite suspicious, while some were entirely unfit for use. A number of samples were found to contain lead, due to the use of lead pipe. Drinking water thus polluted results in serious cases of lead poisoning. All parties are *cautioned never to use lead pipe to conduct water intended for drinking or cooking purposes.*

It has been the custom, ever since the establishment of the Massachusetts Experiment Station, in 1882, to make sanitary analyses of drinking water free of cost to citizens of Massachusetts. Because of the increase of other lines of work, and the limited funds available, it has become necessary to make a small charge for each sample of water examined. Acting under instructions from the Experiment Station committee, the following regulations have been adopted: —

After Jan. 1, 1903, there will be a charge of three dollars for each sample of water tested at this station. This charge is intended to simply cover the cost of the chemist's time and the gas and chemicals employed in the examination. Heretofore, to aid in promoting the public health, sanitary analyses of drinking water have been made free of cost to citizens of Massachusetts, although the station has in no way been required by law to do so. The increase of other important lines of work now severely taxes the limited resources of this division, and renders such a step necessary.

Those wishing to secure a sanitary analysis of water must first apply, whereupon a glass bottle securely encased, accompanied by full instructions for collecting and shipping the sample, will be forwarded by express. The return expressage must in all cases be prepaid. Because of the smallness of the sum involved, no account will be opened. Remittance by check, P. O. money order, or money at the owner's risk, must be strictly in advance.

Application may be made and money sent to

Dr. J. B. Lindsey,
Hatch Experiment Station.

(b) *Dairy Products and Feed Stuffs.*

Slightly less than the usual number of samples of milk and cream were received during the past year. They were sent largely for the purpose of ascertaining their butter fat content. Some farmers wish to ascertain the quality of milk produced by their animals, while others who sell cream wish to check the work of the local creamery. Oftentimes samples are received from milk dealers whose product has been found below the legal standard; in such cases, both total solid matter and fat are determined. Printed circulars are sent to all inquiries, giving concise information concerning the quality of milk produced by different breeds, as well as full instruction relative to the best methods to be employed in determining the butter-producing capacity of dairy herds.

This division also examines milk, cream, butter and oleomargarine collected by the agent of the Dairy Bureau in western Massachusetts. The past year the work has been confined almost wholly to the examination of renovated butter. The number of feed stuffs received was somewhat in excess of those received a year ago. In some cases a physical inspection only was necessary, while in other cases both a chemical and microscopic examination are required. Numerous samples are received from wholesale dealers, who avail themselves of the station facilities to make sure that the materials they are offering are as represented. It is the intention to give such samples immediate attention, and to return the results promptly.

(c) *Chemical Investigation.*

It is the aim of this division to devote as much attention as possible to chemical investigation, in connection with the many dairy and feeding problems. The very limited time at our disposal the past year has been given: (*a*) to the examination of butter fat in connection with feeding experiments, to note the effect of various feed constituents upon its character; (*b*) to the improvement of methods for the determination of the pentosans and starch in feed stuffs; and (*c*) to the determination of the availability of organic nitrogen in fertilizing materials. An inquiry was also conducted to ascertain the effect of two different milk-condensing processes on the nitrogenous bodies of milk.

A great deal of time has also been given to chemical work in connection with the various feeding and dairy experiments. Some of the experiments, being completed, are reported in Part II., while others are still in progress.

D. Cattle Feed Inspection.

During the past year only one complete canvass of the State has been made for the purpose of collecting samples of concentrated feeds; heretofore, at least two inspections were made yearly. More work had been done, however, along this line in the past than the small amount of money available under the law would admit; hence the necessary curtailment. The results of the samples collected and examined for 1901 were published in Bulletin No. 78, of which 9,000 copies were issued. A quite thorough inspection was made in October and November, 1902, and the feeds are now undergoing a chemical and microscopic examination. It may be said that, owing to the unusually open autumn, and because of the expectation that with the advent of new corn the prices of feeds would generally reach a lower level, dealers were carrying light stocks. Little new cotton-seed meal had arrived, and the various gluten products were in light supply. West of the Connecticut River very little material, excepting wheat feeds, was found. As soon as the weather becomes colder, and especially after the new crop of corn becomes available, the quantity and variety of feed stuffs must be greatly increased.

In general, it may be said that the better grades of concentrated feeds, such as cotton-seed meal, linseed meal, the gluten and unmixed wheat products, are practically free from adulteration. Exceptions to this statement are to be found in the frequent admixture of wheat screenings with wheat bran, and in an entire car of so-called "Fancy Canada Bran," containing a very large admixture of coffee hulls, — a worthless feeding material.

Mixed feed, a trade name for a mixture of 1,200 to 1,800 pounds of wheat bran and 200 to 800 pounds of fine middlings and "red dog," is often seriously adulterated by substituting ground corn cobs or broom-corn waste for the middlings. This falsification is not practised by reputable millers, but by unscrupulous outside parties, or possibly by small millers in remote localities. It is hardly necessary to remark that this material is sold at the same price as the genuine. A considerable variety of oat offal is always in the market, and in some cases it is guaranteed to contain a noticeably higher percentage of protein than is shown by analysis. The manufacturers' attention has been called to this misrepresentation, but they do not choose to rectify it. A large amount of so-called provender consists of mixtures of oat offal and cracked corn in place of ground oats and corn. It is believed that this deception is increasing. The larger part of the oat offal in the market is sold at prices much in advance of its value.

Among the new feeds in the market the past year may be mentioned dried distillers' grains, — the residue in the manufacture of alcohol, spirits and whiskey, from the several cereals; and nutrene dairy feed. This latter product is made in Louisiana, and consists of cheap molasses soaked up in oat clippings or similar material, with the addition of a little cotton-seed meal, hulls, etc. Its exact value is at present uncertain.

Attention was called in the last report to the need of a new feed law, and the reasons therefor made as explicit as possible. This need cannot be too strongly emphasized at the present time. A bill has been prepared for presentation at the coming session of the Legislature, and it is hoped it will receive the cordial support of all consumers, as well as reputable manufacturers and dealers.

E. Execution of the Dairy Law.

The text of the law (chapter 202, Acts of 1901) may be found in the report of this station for 1901, page 156. The law naturally resolves itself into three sections: (1) the testing of Babcock glassware for accuracy of graduation; (2) the examination of candidates for proficiency in operating the test; (3) the inspection of Babcock machines.

Inspection of Glassware. — All glassware found to be correct is marked "Mass. Ex. St.," by means of a sand blast. During the first year it was necessary to inspect the ware in use by all creameries and milk depots employing the test; now practically all is received from supply houses that keep tested ware in stock. The total number of pieces examined the present year has been 2,344, of which 56 pieces, or 2.4 per cent., were found incorrect. A year ago 5 per cent. were found improperly graduated. Manufacturers are now very careful concerning the accuracy of their product.

In testing glassware, the following limits of error are allowed: —

	Capacity.	Single Graduation.	Limit of Error.
	Per Cent.	Per Cent.	Per Cent.
Cream bottles, Connecticut,	30–35–40	.50	.50
Cream bottles, Connecticut,	50	1.00	.50
Cream bottles, Bartlett,	25	.20	.20
Milk bottles, common,	10	.20	.20
Milk bottles, Ohlsson,	5	.10	.10
Milk bottles, Wagner,	8	.10	.10
Skim milk bottles, double quantity,	2.00	.10	.10
Skim milk bottles, Ohlsson,	.50	.05	.02
Skim milk bottles, improved Ohlsson,	.25	.01	.01
Skim milk bottles, Wagner,	.50	.05	.02
Skim milk bottles, improved Wagner,	.25	.01	.01
	Cubic Centimetre.	Cubic Centimetre.	Cubic Centimetre.
Pipettes, cream,	18.00	–	.10
Pipettes, milk,	17.60	–	.10
Acid measures,	17.50	–	.20

Examination of Candidates. — Mr. E. B. Holland has taken charge of this work. Last year 45 candidates were examined, being principally the operators in the employ of Massachusetts creameries and milk depots. The present year 13 were examined and given certificates of competency. It is believed that practically all now using the Babcock test as a basis for payment have a good understanding of the process, and are capable of doing satisfactory work.

Inspection of Babcock Machines. — The examination of Babcock machines has been in charge of Mr. N. J. Hunting, who visited each creamery or milk depot, and made a personal inspection of all machines in use. At the time of presenting the last report it was not possible to state the results of the first inspection (1901), which showed 20 machines to be in good condition, 11 to be in need of repairs and 9 to be entirely unfit for satisfactory work. A number of machines needed levelling, and several were without a steam gauge or speed indicator. The condition of a machine frequently depends upon the operator. If he is careful and painstaking in his work, the tester is likely to be found in good repair. The total cost of the first inspection was $182.42, — $4.56 each. It was impossible to exactly apportion the cost of examining each machine, so that it seemed wiser to divide the total cost of inspection by the number of machines examined, the quotient being the cost to each creamery. It became necessary, because of the number of machines out of condition or condemned, to make a second inspection, the cost of which was apportioned as equally as possible among those directly interested. A few managers considered the cost excessive, but it was not possible to do the work for less. Simply because one-half or one hour was occupied in making the actual examination, it must not be understood that the charge should be only for the time thus employed. The entire cost covers the time actually spent en route, including occasional delays, as well as travelling and hotel expense. The proper enforcement of this law has required the expenditure of a great deal of time on the part of the employees of this division without any financial return. The extra labor has been cheerfully given, however, with a belief that it has resulted in positive good to both creameries and patrons.

The inspection for 1902 is in progress at this writing (December 10). The inspector states that he finds nearly all machines now in good working condition, the improvement over last year being quite marked.

It is evident that the creamery law has been of direct benefit to the creameries of the State. It has decidedly improved the accuracy of Babcock glassware, taught many operators to be more careful in making the test, given the majority a better understanding of the principles involved, caused many Babcock machines to be put in proper condition to do accurate work, and replaced worn and antiquated machines with those of modern construction. The total expense to each creamery and indirectly to each patron has been merely nominal.

PART II. — DAIRY AND FEEDING EXPERIMENTS.

J. B. LINDSEY.

A. TESTS OF PURE-BRED COWS.

During the past year this division has made the following milk, butter fat and butter tests for the several cattle associations, in accordance with their prescribed rules : —

Five cows were tested for the Holstein-Friesian Association, to ascertain the amount of milk and butter fat produced during seven consecutive days.

Nine cows are now being tested for the American Guernsey Cattle Club. The amount of milk and butter fat produced in one day of each month is ascertained, and upon this is based the monthly yield.

Two cows are now undergoing a yearly milk and butter fat test for the American Jersey Cattle Club. The amount of milk and fat produced during two consecutive days of each month is ascertained, and upon this product is based the monthly yield.

The tests are all made at the farms of the several owners, by or under the supervision of a representative of this station.

The results of the following confirmed tests, made at the request of the American Jersey Cattle Club, for Mr. C. I. Hood of Lowell, Mass., are sufficiently instructive to warrant their presentation in this report : —

Confirmed Butter Tests at Hood Farm.

Elsie Wolcott.

MILK PRODUCED (POUNDS).	Per Cent. Fat in Milk.	Butter Fat produced (Pounds).	Equal to 85 Per Cent. Butter.		Butter churned.		Fat lost in Skim Milk and Buttermilk, etc. (Pounds).	Fat available for Butter (Pounds).	Fat recovered in Butter (Pounds).
			Pounds.	Ounces.	Pounds.	Ounces.			
258.12	4.96	12.81	15	1	14	10	.207	12.60	12.31
Betsona Khedive La Gros.									
282.00	5.49	15.50	18	4	17	10½	.227	15.27	14.92
Figgis.									
293.44	5.48	16.08	18	15	19	½	.160	15.92	15.85
Sophie Tenth.									
278.06	4.59	12.77	15	–	15	5½	.160	12.61	12.72
Oonan Eighth.									
211.70	5.94	12.58	14	13	14	10½	.109[1]	12.47	12.10
Brown Bessie Forty-Sixth.									
210.38	5.42	11.41	13	7	13	8½	.171	11.24	11.16
Nora of Argyle.									
276.44	5.30	14.65	17	4	16	13	.216	14.43	14.25
Oonan Fourteenth.									
287.56	4.42	12.71	15	–	15	3	.308	12.40	12.41
Hood Farm Belle.									
260.31	4.66	12.13	14	–	14	2	.221	11.91	11.41
Oonan Seventh.									
289.20	4.41	12.74	15	–	14	2½	.820[2]	11.92	11.46

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[1] Fat in buttermilk not included.

[2] Buttermilk contained 1.4 per cent. of fat.

The first three columns show the total milk produced in seven days, the average per cent. of fat it contained, and the pounds of butter fat actually produced by each animal.

The fourth column indicates the equivalent of this butter fat in 85 per cent. butter, and the fifth column shows the amount of butter actually churned. There are no wide variations between estimated and actual butter,[1] which means that the butter was of normal composition.

The sixth column, entitled "Fat lost," etc., means the entire amount of fat contained in the skim milk and buttermilk, and in the milk used in Babcocking. The average per cent. of fat in the skim milk was .031 per cent., and in the buttermilk (excepting Oonan Seventh), .061 per cent. In only two cases did the buttermilk show .15 or more per cent. of fat.

The seventh column shows the fat available for butter, and is obtained by deducting the fat lost in the manufacturing process from the entire quantity of fat produced.

The eighth column contains the quantity of fat actually recovered in the butter, as ascertained by chemical analysis. Theoretically, the seventh and eighth columns should agree. In five out of the ten results this is practically the case; the other five show discrepancies, which must be charged to errors in manipulation. The differences in case of Hood Farm Belle and Oonan Seventh are excessive. Of the 133.38 pounds of fat produced by the ten animals, 128.59 pounds, or 96.41 per cent., were recovered in the butter, showing a loss of 3.59 per cent. in the entire manufacturing process.

The butter was made by the regular Hood farm butter maker. Samples of each lot were taken at once by the tester, and sent to the Experiment Station for analysis. In six cases two lots of butter were made from the cream produced in seven days, and in four cases the entire cream produced during the period was churned at one time. The following table gives the analysis of the butter made from the fat produced by each animal: —

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[1] There is one exception in case of Oonan Seventh, due to the loss of considerable fat in the buttermilk.

Analyses of Butter.

CONSTITUENTS.	Elsie Wolcott.	Betsona.	Figgis.	Sophie Tenth.	Oonan Eighth.	Brown Bessie Forty-sixth.	Nora of Argyle.	Oonan Fourth.	Hood Farm Belle.	Oonan Seventh.
Water,	11.45	11.74	14.36	13.98	15.37	13.56	12.37	13.28	16.23	14.45
	14.27	14.24	13.30		14.35	14.63		16.91		
Fat,	86.37	85.34	82.87	82.98	82.23	83.27	84.82	83.81	80.75	81.00
	81.80	83.40	83.96		82.55	82.00		78.98		
Salt,	1.38	2.01	1.98	2.28	2.00	2.49	1.91	2.24	2.76	3.39
	3.13	1.70	1.87		4.00	2.60		3.39		
Curd,	.80	.91	.79	.76	.40	.68	.90	.67	.26	1.16
	.80	.66	.87		.70	.77		.72		

The extremes in the percentage of butter fat were 78.98 and 86.37 per cent., and in the percentage of water, salt and curd, 13.63 and 21.02. The average composition of the 16 samples was: water, 14.03 per cent.; fat, 82.88; salt, 2.45; and curd, .74.

The Babcock machine in the hands of the tester has shown how much butter fat the cow has actually produced, and how much has been lost in the process of manufacturing the same into butter. The chemist has demonstrated the amount of butter fat actually recovered in the form of butter, and his results in eight out of the ten cows closely agree with those obtained by the Babcock machine (total butter fat produced minus fat lost). The chemist further gives evidence that the butter produced, while it varied somewhat in composition, was of normal character.

It is clear from the above data that the amount of butter fat produced by the cow furnishes, to say the least, accurate and consequently satisfactory evidence of her butter-producing capacity.

The results, taken as a whole, reflect much credit upon the work done by the testers and butter maker.[1]

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[1] These confirmed tests were made by Messrs. F. R. Church, W. A. Conant, E. S. Fulton and B. Tupper. In each case the work was very carefully done.

B. Tests of Fly Preventives.

For the past two years this division has made a trial of a number of so-called fly removers. These materials are generally sold at retail for from one to one and one-half dollars a gallon. No effort was made to ascertain the exact composition of each. They appeared to consist largely of some oil such as crude petroleum, to which more or less pine tar had been added. In one case fish oil was noticed, and in another light coal tar oil. When not too thick, they were applied with a Woodason or Aspinwall sprayer; otherwise, a four-inch varnish brush, dipped in the liquid, was very lightly drawn over the animals. The latter method is less satisfactory, for the reason that it is hardly possible to avoid putting on an excess; in which case it forms a sticky mass with the hair, to which the dust adheres, giving the animals a very untidy appearance.

Brands and Manufacturers.

Brand.	Manufacturer.	Location.
1. Sure Thing, . . .	Empire State Shaft Coupling Company.	Utica, N. Y.
2. Cattle Comfort, . .	Hammond Slug Shot Works, . .	Fishkill, N. Y.
3. Stop Fly, ...	Standard Oil Company, . . .	New York, N. Y.
4. Norwood Sanitary Fluid,	Smith, Kleine & French Company, .	Philadelphia, Pa.
5. Flylene, ...	American Glucose Works, . .	Camden, N. Y.
6. Shoo Fly, ...	Shoo Fly Manufacturing Company,	Philadelphia, Pa.
7. Eli Fly Chaser, . .	Vail Seed Company, ...	Indianapolis, Ind.
8. Eureka, ...	J. H. Ames Company, . . .	Bowdoinham, Me.
9. Rippley's Fly Remover, .	Rippley Hardware Company, . .	Grafton, Ill.
10. Cyphers Anti-fly Pest, .	Cyphers Incubator Company, . .	Boston, Mass.

Results with Cows.

The cows were treated in the morning before being turned out in the yard, and again at night before milking. They were observed at frequent intervals during the day, in order to note the effect of each particular brand.

1. *Sure Thing.* — Applied as spray. Keeps off flies for a short time, but not lasting in its effects.

2. *Cattle Comfort.* — Applied as spray. Not very satisfactory.

3. *Stop Fly.* — Applied as spray. Favorable effect disappeared in one-half hour.

4. *Norwood Sanitary Fluid.* — Applied as spray. This material is unquestionably crude creolin; it is very valuable as a disinfectant, but not satisfactory as a fly remover.

5. *Flylene.* — Very effective, keeping the flies off for a long time.

6. *Shoo Fly.* — Applied with brush. It was fairly effective in keeping off small flies, but not the large house fly.

7. *Eli Fly Chaser.* — Applied with brush. Same as No. 6.

8. *Eureka.* — Fairly satisfactory. Weather cool, and trial consequently not as thorough as others.

9. *Rippley's Fly Remover.* — Keeps small flies off for a short time. One year's trial.

10. *Cyphers.* — Keeps flies off for a short time. Only one year's trial.

Tests with Other Substances.

11. *Light Coal Tar Oil.* — This is the lighter of the two oils derived from tar. It was obtained through the courtesy of the Pocahontas Collieries Company, Pocahontas, Va. It appears as a dark, thin oil, with a strong creosote odor. It was applied as a spray, and gave quite satisfactory results.

12. *Recommended by J. M. W. Kitchen, M.D.* — One pound resin, one-half pound caustic potash, two pounds whale oil soap (chipped), two quarts water. Boil these until all united into a smooth liquid, then add one pound pine tar and one pint kerosene. Thin down if necessary with water and kerosene. This mixture was quite thick and heavy. It was applied lightly with a brush, but was not effective.

13. *Recommended.* — One-half tea cup bi-sulphide carbon, in which dissolve one tablespoonful pine tar, stirring thoroughly until tar is dissolved, and then add one quart kerosene or crude petroleum, and apply as a spray. This mixture was quite effective for a few hours, until the carbon bi-sulphide had evaporated. It must be kept in glass-stoppered bottles.

Results with Horses.

The agricultural division of this station gave a number of these articles a test with work horses, applying the same with an Aspinwall sprayer.

1. *Sure Thing.* — Keeps flies off well for about five hours; the large green fly does not mind it. Gums horse some.

2. *Cattle Comfort.* — Lasts about three-fourths of a day. Gums horses.

3. *Stop Fly.* — Ineffective.

4. *Norwood Sanitary Fluid.* — Ineffective.

5. *Flylene.* — Keeps flies off well, and gums horses but little. Very satisfactory.

6. *Eli Fly Chaser.* — Quite satisfactory, and equal to No. 5. Does not gum badly.

7. *Eureka.* — Same as No. 6.

8. *Cyphers.* — Protects for short time only and gums badly.

General Conclusions.

(*a*) Quite satisfactory: 1. Flylene; 2. Eureka; 3. Eli Fly Chaser; 4. Shoo Fly; 5. Light coal tar oil.

(*b*) Less satisfactory: 1. Sure Thing; 2. Cattle Comfort; 3. Rippley's Fly Remover; 4. Cyphers Anti-fly pest; 5. Recommended mixture No. 13.

(*c*) Unsatisfactory: 1. Norwood Sanitary Fluid; 2. Stop Fly; 3. Recommended mixture No. 12.

The only objection to those marked "quite satisfactory" is their cost. It is hoped that we shall be able to find some cheaper and equally effective substance or mixture. The most promising substance is the light coal tar oil. Even at the present cost of the commercial articles, it is believed their use is warranted, because cows remain much quieter, and horses work better and require less attention from the driver.

C. SUMMER FORAGE CROPS.

(*a*) *Winter Wheat and Sand or Hairy Vetch.*

This mixture of a non-legume and legume has been tried for a number of years at the station, and has proved to be an early and desirable spring green fodder. The only objection is to be found in the present cost of the vetch seed, — $5 or more a bushel. This excessive cost is due to the fact that the vetch is a poor seeder, and frequently sheds its seeds before they can be harvested.

History of the Several Trials. — The first planting of this mixture, Aug. 1, 1898, winter-killed, in all probability, owing to the fact that the seed was sown too early.

The second planting, made Aug. 25, 1899, in the proportion of 2 bushels of wheat to 1½ bushels of vetch, wintered well, and made a fine spring growth. Cutting began May 31, and the yield was at the rate of 10 tons to the acre.

The third planting was made Aug. 24, 1900, with equal quantities of wheat and vetch seed. The autumn of that year was extremely dry, and the wheat killed out to some extent, so that the vetch predominated. The following spring was wet and cold, — a condition which appeared to favor the growth of the vetch at the expense of the wheat. At the time of cutting, May 30, the vetch had completely covered the wheat in spots, and had lodged badly. The vetch roots were full of the characteristic nodules. The weight of the entire yield was not obtained, but a conservative estimate places it at 6 to 7 tons to the acre.

The fourth planting (⅓ acre), made Sept. 3, 1901, at the rate of 1½ bushels of Rural New Yorker No. 6 wheat and 1 bushel of vetch to the acre, wintered well, and cutting began May 28, at which time the mixture was from 2½ to 3 feet high. At that time the wheat was about ready to show the head, and scattered vetch blossoms were noticed. When in full bloom the mixture stood from 3½ to 4 feet high. The total yield was 6,545 pounds, equivalent to 9.5 tons to the acre.

Further Use of the Land. — Immediately after the removal of this crop the land was ploughed, a light dressing of manure applied, and seeded with Longfellow corn. A yield (the past season) of 35,362 pounds (17.68 tons) of fairly well-eared green fodder to the acre was secured. The land was light and the rainfall excessive, which conditions were favorable, excepting lack of heat, for fodder production. The total product of this piece of land for one year (first sown to wheat and vetch, and followed by corn) was at the rate of 8,622 pounds of dry matter to the acre, being equivalent to fully 5 tons of well-cured hay. It is not to be expected that such quantities could be obtained yearly under average conditions, for the land could not be as fully utilized. It is interesting to note, however, the quantity of fodder that may be secured from an acre of land in an average state of fertility, when climatic conditions are favorable and the land is occupied the entire season.

Best Method of growing Wheat and Vetch. — The land should be ploughed, harrowed if necessary, manure spread at the rate of 4 to 6 cords to the acre,[1] harrowed in; a mixture of 1½ bushels of wheat and 1 bushel of vetch sown broadcast about September 1, and covered, not too deeply with a wheel or other harrow. Cutting should begin just before the wheat heads appear, which in this locality is the last of May. The green crop will remain in feeding condition for twelve to fourteen days. If more of the fodder mixture has been produced than can be fed green, the balance may be made into hay. The vetch seed may be procured of New York seedsmen.

Composition of Wheat and Vetch.

CONSTITUENTS.	GREEN FODDER.		DRIED FODDER.	
	No. 1.	No. 2.	No. 1.	No. 2.
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Water,	83.40	79.60	11.90	13.70
Ash,	1.50	1.76	7.97	5.22
Protein,	3.25	3.14	17.07	10.93
Fibre,	5.13	5.98	28.38	29.51
Extract matter,	6.24	8.92	32.52	38.70
Fat,	.48	.60	2.16	1.94
	100.00	100.00	100.00	100.00

The percentage of protein in the mixture is dependent to an extent upon the quantity of vetch present. In case of sample No. 1 of both the green and dry fodder, the vetch predominated. In case of sample No. 2 of the dry fodder, the wheat was probably in excess. In fodder combinations it is difficult to secure an even distribution of the several plants. The mixture of 1½ bushels of wheat and 1 bushel of vetch per acre is satisfactory, does not lodge, and will show from 12 to 15 per cent. of protein in a thoroughly air-dry condition.

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[1] Fertilizer may be used in place of manure, at the rate of 50 pounds of nitrate of soda, 300 pounds of acid phosphate and 200 pounds of muriate of potash to the acre. In the spring a top-dressing of 50 to 100 pounds of nitrate of soda will prove beneficial.

Digestibility of Winter Wheat and Sand Vetch. — Five digestion trials have been made with two different samples of green fodder, and six trials with two samples of the dried material: —

Series.	FODDERS.	Number of Trials.	Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Extract Matter (Per Cent.).	Fat (Per Cent.).
VI.	Wheat and vetch (green), .	3	67.54	42.47	76.27	66.05	71.13	55.65
VII.	Wheat and vetch (green), .	2	70.13	43.59	70.92	70.50	75.05	57.92
	Average, ...	5	68.58	42.92	74.13	67.83	72.70	56.56
VII.	Wheat and vetch (dry), same as Series VI. (green).	3	68.33	59.41	76.86	64.47	69.71	63.46
VII.	Wheat and vetch (dry), . .	3	64.50	35.20	70.77	64.59	66.75	63.75
	Average, ...	6	66.42	47.31	73.82	64.53	68.23	63.61
	Dent fodder corn (milk), for comparison.	9	70.00	-	61.00	64.00	76.00	78.00
	Oats and peas (bloom), for comparison.	5	70.00	49.00	74.00	64.00	72.00	64.00

The several digestion trials make it clear that the wheat and vetch mixture is as digestible as either fodder corn or oat and pea fodder. They also show this fodder when dried under normal conditions to be as digestible as when fed green.

General Conclusions.

1. Wheat and sand vetch is a hardy fodder mixture.

2. When sown the previous autumn, it will be ready to cut the last of May, and is considered preferable to rye.

3. It will yield about 10 tons of green material to the acre under average conditions, and in composition, digestibility and feeding value it fully equals peas and oats and similar crops.

4. Because of the present cost of vetch seed, it is doubtful if the ordinary dairyman can afford to grow it; but the milk producer in the vicinity of profitable markets, who cultivates intensively, may find it a satisfactory source of early green feed.

5. Wheat seeded by itself in early September makes a fairly satisfactory early soiling crop, and is to be preferred to rye.

6. The dried wheat and vetch fodder if cut when in bloom is preferable to ordinary hay for milk, but, on account of the increased cost of production, it would hardly be considered profitable as a hay substitute.

(*b*) *Corn and Soy Beans.*

Attention has already been called (in Bulletin No. 72) to the value of this fodder combination for August and September soiling. The present season about one-third of an acre was grown. In early September the beans were podding and the corn was fairly well eared, but the ears were only partially developed. The mixture was cut and bound successfully October 4, with the Deering corn harvester, at which time the bean stalks were quite tough, the bean pods filled and the corn kernels glazed. This is the first attempt made to cut the corn and bean mixture with a harvester. A larger area will be planted another season, in order to see if the mixture can be economically handled for silage.

Corn and soy bean silage was grown and used at this station during 1895 and 1896. At that time the corn and beans were grown in separate fields. The silo was filled in the proportion of two-thirds corn and one-third beans. The silage was satisfactory, eaten clean, and furnished 30 per cent. more protein than did corn silage. It was believed at the time, however, that the increased cost of handling the two crops when grown separately more than counterbalanced the value of the additional protein secured. If it proves economical to grow and handle the two together, it will in a measure aid in increasing the supply of home-grown protein.

(*c*) *Soy Beans v. Cow Peas.*

Much is being said in the agricultural press concerning the home production of protein, and this division receives frequent inquiries concerning the relative merits of soy beans and cow peas for this purpose.[1]

During the past season the following varieties of cow peas were tested: Whippoorwill, Black, Extra Early Black and Warren. Although seeded the first of June, they grew but little until late in July, the unusually cool season being decidedly unfavorable to their development. The Whippoorwill and Black produced a few blossoms early in September. The former yielded about 5 and the latter 7 tons of green fodder to the acre. The seed of the Whippoorwill did not come up as well as did the Black.

The Extra Early Black seeded fully in September, but the growth was not sufficient to warrant its use for green feed.

The Warren blossomed some, but did not grow to sufficient size to be suitable for forage purposes.

The Whippoorwill and the Black are probably the best suited to northern conditions.

In comparing the relative merits of the two legumes, it may be said that the stem of the cow pea is softer than that of the soy bean, and that the crop does its best in very warm weather, and is likely to succeed better than the soy bean upon light, sandy soils, naturally deficient in moisture.

The medium green soy bean, on the other hand, prefers a medium moist loam, and will yield more dry food material, and especially more seed to the acre at moderate temperatures, than the cow pea. The cow pea is better suited to southern, and the soy bean to northern conditions, and the latter is regarded as decidedly preferable in New England.

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[1] This division is giving what is termed the "protein problem" considerable attention. While the growing of soy beans, cow peas and clover will in many cases prove economical, it is believed that the majority of Massachusetts dairymen will be obliged to purchase at least a portion of their protein in the form of cotton-seed meal, gluten or other nitrogenous meals, and depend upon the farm for the production of the carbohydrates in the form of hay and corn.

D. The Pentosans.

J. B. LINDSEY.

(a) *Character of Plant Tissue.*

Various investigations have shown that the larger part of the cellular structure of vegetables and coarse fodders consists:[1] (1) of substances insoluble in water, but soluble in dilute mineral acids, and which are classified as hemi-celluloses; (2) of substances insoluble to any extent in dilute mineral acids, alkali, or F. Schulze's reagent, and which are turned blue by sulphuric acid and iodine, namely, the true celluloses; (3) of lignin acids, which compose one-third to one-half of the true woods, but exist only in small quantities, if at all, in the soft new cells of young plants and vegetables.

Under the hemi-celluloses[2] belong the mother substances dextran, lævulan, mannan, galactan and pentosans (araban and xylan), which on inversion yield dextrose, lævulose, mannose, glactose, arabinose and xylose. These hemi-celluloses are intermixed and perhaps chemically united to the true celluloses and ligno-celluloses in the cell walls of plants and seeds. In some cases they have been recognized as reserve material, and are used as food in the sprouting of the seed.

The true celluloses, upon being dissolved in strong sulphuric acid, and the resulting product hydrolyzed with dilute acid, yield dextrose as a rule, hence the name dextroso cellulose. Schulze has also recognized mannose and xylose, consequently there exist dextroso, mannoso and pentoso celluloses.

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[1] This classification does not include amyloid, a substance soluble in water, and yielding various sugars by hydrolysis. See Winterstein, Zeitsch. f. physiol. Chem., 15, 1892; also Agricultural Science, 1893, p. 162.

[2] See various publications of E. Schulze in Zeitsch. f. physiol. Chem.

The lignin acids are probably strongly united to the dextroso cellulose, and it seems reasonable to suppose also to the pentoso cellulose.

(*b*) *Recognition of the Pentosans.*

By treating wood with dilute alkali, and precipitating the extracted material with alcohol and hydrochloric acid, Th. Thomson[1] obtained a substance termed wood gum (Holzgummi) ; and by inversion Koch[2] secured wood sugar or xylose, which was carefully examined by Wheeler,[3] Allen[4] and Tollens, and declared to be a pentose ($C^5H^{10}O^5$). The mother substances in wood gum and also in cherry gum[5] contain less water than the pentoses, and are termed pentosans ($C^5H^8O^4$). The substance yielding xylose was termed xylan, and that yielding arabinose, araban.

(*c*) *Methods for Determination of Pentosans.*

After wood gum and the resulting sugar had been carefully studied, it became necessary to obtain a method for their quantitative determination, in order to note to what extent they occurred, especially in agricultural products. The first experiments were made by Stone, Wheeler, Allen and Tollens,[6] by dissolving the substance in hydrochloric acid, precipitating the furfural with ammonia, and weighing the resulting furfuramid.

Gunther[7] and Tollens distilled with hydrochloric acid of 1.06 specific gravity, and titrated the distillate with acetate of phenylhydrazine, using analine acetate as indicator.

Stone[8] proposed a method in which he titrated the distilled furfural with a dilute solution of phenylhydrazine of known strength, using Fehling solution as indicator.

De Chalmot[9] and Tollens precipitated the furfural distillate with acetate of phenylhydrazine, dried and weighed the precipitate in glass tubes. This method was further studied and improved by Flint,[1] Mann[2] and Tollens, and was designated the phenylhydrazine method. The Association of Official Agricultural Chemists adopted this method at its meeting in 1895, and later it was slightly modified by Krug.[3]

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[1] Journal for Pract. Chem., 19, (2) p. 146.

[2] Pharm. Zeitsch. für Russland, 25, p. 619, 635, 651.

[3] Liebig's Ann. Chem., 254, p. 304.

[4] Liebig's Ann. Chem., 260, pp. 289-306.

[5] From cherry gum, Scheibler first obtained the arabinose ($C^5H^{10}O^5$).

[6] Loco citato.

[7] Berichte, 23, p. 1751; 24, p. 3575.

[8] Journal of Analyt. and Applied Chem., Vol. V, No. 8, p. 421.

[9] Berichte, 24, p. 3579.

Hotter[4] recommended that, in place of phenylhydrazine, a portion of the furfural distillate be heated in closed glass tubes with pyrogallol, and that from the weight of the resulting precipitate be calculated the percentage of furfural.

Counciler[5] suggested that phloroglucol be employed instead of the pyrogallol, for the reason that the union of the furfural with the phloroglucol would take place at ordinary temperature. Krüger,[6] Rimbach[7] and Tollens studied and perfected the method, and recommended it as reliable for the determination of pentosans in coarse fodders, grains and vegetables. The Association of Official Agricultural Chemists adopted the phloroglucol method as recommended by Krüger and Tollens in 1897, as a provisional method with slight modifications, the most important of which was the use of the Gooch crucible in place of filter paper for collecting the precipitate. Kröber[8] and Tollens have recently published the results of a very exhaustive investigation of the phloroglucol method, together with a complete table for converting any weight of phloroglucid between .030 and .300 gram into furfural, arabinose, araban, xylose, xylan, pentose and pentosans. The principal conclusions were as follows: —

1. That the results are not influenced by the length of time (over fifteen hours) the precipitate stands.

2. That the phloroglucid is best collected in a Gooch crucible.

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[1] Berichte, 25, p. 2912; Landw. Vers. Stat., 42, p. 381.

[2] Zeitsch. f. Angw. Chem. 1896, p. 33, 194.

[3] Bulletin 49, Division of Chemistry, U. S. Department of Agriculture.

[4] Chemiker Zeitung, 1893, p. 1743.

[5] Chemiker Zeitung, 1894, No. 51.

[6] Zeitsch. für Angw. Chem., 1896, Heft 2.

[7] Inaug. Diss. Göttingen, 1898.

[8] Journal f. Landw., 1900, p. 357; 1901, p. 7.

3. That the precipitate should be washed with small quantities of water, and should not be allowed to become dry during the washing.

4. That the presence of diresorcol in the phloroglucol does not affect the results.[1]

5. That the precipitate be dried four hours in a water bath, and that the Gooch crucible be kept in a glass bottle during the drying, and be weighed in the glass-stoppered bottle after cooling, in order to prevent the hydroscopic phloroglucol from taking on water.

The Association of Official Chemists at its 1902 meeting adopted Kröber's formulæ and tables for calculating the results.

While the phloroglucol method has been perfected, it can still be regarded only as a conventional method. Furthermore, the fact must not be overlooked that other substances besides pentosans yield furfural. Thus Tollens[2] and his earlier pupils have shown that glycuronic, euxanthic and urochloralic acids yield furfural on distillation with hydrochloric acid, and Cross and Bevan[3] have obtained furfural from oxycellulose. Widstoe[4] and others[5] have also shown that methyl pentosans $C^5H^7(CH)^3O^4$ frequently accompany the true pentosans, and upon distillation yield methyl furfural $C^5H^3(CH)^3O^2 + 2H^2O$ and is likewise precipitated by phloroglucol. Fraps[6] finds that the hydrochloric acid distillate from hay yields on standing, besides furfural, a black precipitate and other substances which are precipitated by phloroglucol. These latter he termed furaloids.

Cross and Bevan[7] have applied the term furfuroids in place of pentosans to all furfural-yielding substances. Tollens, on the other hand, as well as Stone,[8] believe it preferable to retain the old name.

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[1] This statement has been disputed by American chemists (see especially Fraps, Bulletin No. 172, North Carolina Experiment Station).

[2] Loco citato.

[3] Berichte, 27, p. 1061.

[4] Berichte, 33, p. 143.

[5] Zeitsch. für Angw. Chem., 1902, Heft 20, p. 481.

[6] Am. Chem. Jour., 25, p. 501.

[7] Chemical News, 1894; Am. Chem. Jour., 22, p. 634.

[8] Chemical News, 1895, p. 40.

(*d*) *Perfected Methods*[1] *for the Determination of the Pentosans. — Present Phloroglucol Method.*

Reagents.

Twelve per cent. hydrochloric acid (specific gravity 1.06): 275 c.c. conc. acid (specific gravity 1.20) to 725 c.c. water; test with a hydrometer as 15° C.

Phloroglucol solution (purified): 11 grams are dissolved in 300 c.c. hot 12 per cent. acid by constant stirring, made up to 1,500 c.c. with cold acid, allowed to stand several days for the diresorcinol to crystallize out, and filtered immediately before use.

Pumice stone: the stone is prepared by dropping it at white heat into distilled water, and leaving it there until required.

Aniline acetate (test solution): equal parts of aniline and 50 per cent. acetic acid.

Apparatus.

Erlenmeyer flask, 300 c.c.; Liebig condenser and Aubrey connecting tube; separatory funnel (open); graduated cylinders; beaker, 25 ounce; Gooch crucible.

Method.

A weight[2] of material[3] that will not yield over .300 gram of phloroglucid is brought into a 10-ounce Erlenmeyer flask, together with 100 c.c. of 12 per cent. hydrochloric acid and several pieces of pumice stone. The flask, placed on a wire gauze, is connected with a Liebig condenser, and heat applied, gently at first, and regulated so as to distil over 30 c.c. into a graduated cylinder in ten minutes. The 30 c.c.

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[1] The phenylhydrazine method will be found described in the twelfth report of the Massachusetts State Experiment Station, p. 177, and in Bulletin No. 51, Division of Chemistry, U. S. Department of Agriculture. The phloroglucol method, as used in this laboratory for a number of years, is described in Bulletin No. 51, just referred to, and in the ninth report of the Hatch Experiment Station, p. 97.

[2] With material containing pentosans: 30 per cent., take 1 gram of material; 25 per cent., take 1.25 grams of material; 20 per cent., take 1.50 grams of material; 15 per cent., take 2 grams of material; 10 per cent., take 3.25 grams of material; 5 per cent., take 5 grams of material.

[3] Previous extraction with ether is not warranted, except with materials of a high fat content.

driven over are replaced by a like quantity of dilute acid by means of an "open-top" separatory funnel, the flask agitated to wash down the particles adhering to the sides, and the process continued until the distillate amounts to 360 c.c.[1]

The completed distillate is filtered to remove insoluble fats into a 25-ounce lipped beaker, graduated at 500 c.c., and 50 c.c. of phloroglucol solution gradually added, precipitating the furfural as phloroglucid, and the mixture thoroughly stirred. The solution is made up to 500[2] c.c. with 12 per cent. acid, and allowed to stand at least fifteen hours.

The amorphous black precipitate is filtered under pressure into a tared Gooch through an asbestos felt, washed carefully, never allowing it to become dry, with 150 c.c. of water, dried at 100° C. to a constant figure, weighed in a glass-stoppered bottle, and the increase reckoned as phloroglucid, from which furfural, pentosans, etc., can be calculated by the following formulæ: —

1. Less than .300 Gram Phloroglucid.

1. Furfural = (weight of the phloroglucid + .0052) × .5170
2. Pentosans = (weight of the phloroglucid + .0052) × .8935
3. Pentose = (weight of the phloroglucid + .0052) × 1.0156

2. More than .300 Gram Phloroglucid.

1. Furfural = (weight of the phloroglucid + .0052) × .5180
2. Pentosans = (weight of the phloroglucid + .0052) × .8822
3. Pentose = (weight of the phloroglucid + .0052) × 1.0025

Kröber has published very complete tables for calculating the results, which will soon be reproduced by the Association of Official Agricultural Chemists.

(e) *Digestibility of the Pentosans.*

The investigations of Günther, De Chalmot, Flint, Mann, Krüger, Glaubitz, Kröber and Tollens, Cross and Bevan,[3]

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[1] Theoretically, the process should be continued as long as the distillate gives a reaction with aniline acetate on filter paper, but 12 distillates are usually considered sufficient.

[2] Tollens advises 400 c.c., but in this laboratory 500 c.c are preferred.

[3] Loco citato.

Winterstein,[1] Stift,[2] Stone,[3] Lindsey and Holland,[4] Wittmann[5] and others, have shown the pentosans to be very widely distributed in plants and seeds, and this general distribution naturally leads to an inquiry as to their nutritive value in the animal economy. Several investigations have been published relative to the ability of both men and animals to assimilate the sugars, xylose and arabinose. Ebsten[6] fed 25 grams of these sugars to men, and found this amount in the urine in a short time. Cremer,[7] on the other hand, found only 10 grams of arabinose in the urine after feeding 25 grams to a healthy man. Salskowski[8] concluded that rabbits were able to assimilate a portion of this sugar, and that as a result the per cent. of glycogen in the body is materially increased. Frentzel's[9] investigations indicated that glycogen could not be formed from xylose in the animal organism, that the xylose prevented the destruction of substances that naturally produced glycogen, thus causing an increase in the amount of this animal sugar in the body. Salskowski[10] found that a rabbit and hen excreted only a fifth of the arabinose fed.

Cross, Bevan and Remington[11] digested brewers' grains with 1 per cent. sulphuric acid in an autoclave at 130° C., neutralized, with carbonate of lime, filtered, evaporated the solution, and obtained 39.5 per cent. of furfural in the dry matter. The evaporated product, when mixed with gelatine and bread and fed with vegetables to rabbits, proved to be 94.5 to 98.4 per cent. digestible, no furfural or pentoses being recognized in the urine. The investigators claim that, when fully hydrolized, these substances are as digestible as starch and its hydrolized product; and in this respect they differ from the pentoses and their anhydrides. J. König and F. Reinhardt[1] report experiments with a man in which canned peas, dried peas and other foods rich in pentosans were added to a mixed diet. The results indicated that the pentosans were very thoroughly digested and assimilated.

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[1] Zürcher Diss., 1892, p. 31.

[2] Osterr. Unger. Zeitsch. für Zücherindustrie, 1894, p. 925.

[3] Agricultural Science, 5, p. 6.

[4] Twelfth Report of Massachusetts Experiment Station, 1894, p. 175; Agricultural Science, 8, p. 162; Proceedings of the sixteenth meeting of the Society for the Promotion of Agricultural Science, 1895.

[5] Zeitsch. Landw. Versuchst. Osterr., 4, pp. 131–139. Abs. Exp. Sta. Rec., 13, p. 420.

[6] Centralblatt f. die medicin. Wissenschaften, 1892, p. 577.

[7] Zeitsch. f. Biologie, 24, p. 484.

[8] Centralblatt f. die medicin. Wissenschaften, 1893, p. 193.

[9] Archw. f. d. ges. Physiologie, 56, p. 273.

[10] Zeitsch. Physio. Chem., 1895, p. 491.

[11] Journal of the Am. Chem., Sec. 22, p. 633.

A number of experiments have been made with farm animals, to study the digestibility of the pentosans. In 1892, Stone[2] fed corn meal and wheat bran to rabbits, and found that about 60 per cent. of the pentosans did not reappear in the fæces. A like conclusion was drawn a year later by Stone and Jones[3] from hay and different grasses fed to sheep. Lindsey and Holland[4] fed hay and different grains to sheep, and found from 55 to 90 per cent. of the pentosans digested, traces only being recognized in the urine. Weiske and Wicke reported similar results.[5] Sherman[6] found the pentosans in wheat bran to be 66.2 per cent. digested. Fraps[7] determined the digestibility of pentosans in a number of cattle feeds. The pentosans in the crude fibre he termed pseudo-pentosans, which proved less digestible than what he termed the true pentosans, as found in the nitrogen-free extract.

In addition to the experiments already reported,[8] the writer[9] has made a number of others with different varieties of hays and grains.

The table which follows contains the percentage and digestion coefficient of the pentosans, and, for the sake of comparison, the percentages and digestion coefficients of each of the other groups of substances in the several feed stuffs.

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[1] Zeitsch. Untersuch. Nahr. u. Genussmtl., 1902, No. 3, pp. 111-116.

[2] Am. Chem. Journal, 14, p. 9.

[3] Agricultural Science, 5, p. 6.

[4] Twelfth report of Massachusetts State Experiment Station, p. 175; report of the Society for Promotion of Agricultural Science, 1895, p. 54.

[5] Zeitsch. f. physiol. Chem., 20, p. 489.

[6] Journal of the Am. Chem., Sec. 19, p. 308.

[7] North Carolina Experiment Station, Bulletin No. 172.

[8] Loco citato.

[9] Together with E. B. Holland.

It includes all experiments made at this station to determine the digestibility of the pentosans.

Description of Feed Stuffs.

English Hay. — Largely Kentucky blue-grass, with a sprinkling of timothy, red-top, meadow fescue and sweet vernal grass, together with some clover.

Millet Hay. — *Panicum crus-galli.* The cultivated species of barnyard grass from Japan, now known as barnyard millet.

Black Grass. — *Juncus Gerardi.*

Fox Grass. — *Spartina patens.*

Branch Grass. — *Distichlis spicata.*

Cove Mixture. — A mixture of black grass and red-top.

Salt Mixture. — A mixture of fox grass and branch grass.

Flat Sage. — *Spartina stricta maritima* var. A variety of creek sedge or thatch. It rarely blossoms, and is easily recognized by its pale-green color.

Buffalo Gluten Feed. — The residue in the manufacture of starch from corn. It contains the gluten, bran and some broken germs. This is an old-process meal. In the new process the oil is largely removed.

New and Old Process Linseed Meals. — Crushed flax seed, after the oil has been expressed. The former is treated by the naphtha process, and the latter by warm pressure.

Atlas Meal. — The dried residue in the process of manufacturing alcohol, spirits and whiskey from the several cereals.

Peanut Feed. — Ground peanut husks.

Composition and Digestibility of Feed Stuffs, with Especial Reference to the Pentosans (Per Cent.).

Series.	FEED STUFF.	COMPOSITION (DRY MATTER).						DIGESTIBILITY.					
		Ash.	Protein.	Fibre.	Extract Matter.	Fat.	Pentosans.	Ash.	Protein.	Fibre.	Extract Matter.	Fat.	Pentosans.
00,	English hay (a),	6.58	11.10	30.33	48.51	3.48	19.80[1]	-	63.49	64.46	63.32	51.43	63.25
0,	English hay (a),	7.09	11.17	32.09	46.42	3.23	20.84[1]	-	59.77	63.69	60.60	51.49	64.79
III.,	English hay (a),	5.53	9.49	32.23	49.53	3.22	22.15	-	58.48	58.64	60.73	50.78	-
00,	English hay (b),	7.83	10.79	32.74	45.56	3.08	21.87[1]	-	57.32	57.14	57.85	46.90	62.54
IV.,	English hay (b),	6.34	10.04	32.67	48.53	2.42	22.25	46.25	61.22	64.96	63.17	49.51	63.95
0,	English hay (d),	7.63	9.74	32.96	47.26	2.41	20.76[1]	-	58.10	57.29	56.69	46.82	57.36
I.,	Meadow or swale hay,	6.20	7.97	31.06	52.90	1.87	18.25	-	33.88	32.97	46.03	43.60	28.62
IV.,	Barnyard millet hay,	10.18	10.73	34.48	43.05	1.56	23.35	63.15	63.67	61.59	51.58	46.34	60.66
III.,	Black grass,	7.87	8.71	28.71	52.23	2.48	24.95	68.97	54.29	57.35	49.04	45.71	47.69
I.,	Black grass,	11.67	9.51	26.80	49.54	2.48	25.22	-	62.88	60.50	56.34	41.45	63.13
I.,	Fox grass,	8.14	7.48	26.41	55.46	2.51	25.75	-	62.70	50.37	53.26	46.64	45.40
I.,	Fox grass,	5.84	7.13	26.57	57.89	2.57	28.20	-	57.00	51.30	52.00	23.80	48.96
III.,	Fox grass,	7.51	8.76	26.96	54.31	2.46	26.37	58.24	59.30	57.40	53.12	36.39	50.31
I.,	Branch grass,	10.29	8.27	26.47	52.76	2.21	26.42	-	62.26	52.25	53.78	31.48	53.50
III.,	Branch grass,	7.85	7.87	26.46	55.00	2.82	26.15	58.13	51.69	56.41	45.74	36.65	44.81
III.,	Cove mixture,	7.19	8.82	27.57	54.32	2.10	22.24	57.50	47.92	59.68	53.19	40.33	53.18
III.,	Salt mixture,	9.98	6.48	26.77	54.26	2.51	24.09	68.77	41.72	57.51	52.28	27.90	48.52

IV.,	Flat sage,	9.79	7.82	29.71	49.77	2.91	**23.82**	61.96	51.77	60.42	55.05	36.14	**58.05**
00,	Buffalo gluten feed,	.78	26.35	8.38	50.20	14.29	**16.64**[1]	-	84.95	43.10	81.40	81.41	**79.32**
0,	Buffalo gluten feed,	.40	22.93	8.46	54.89	13.32	**17.22**[1]	-	87.13	88.94	86.92	93.17	**85.08**
00,	New-process linseed meal,	5.84	40.40	8.59	41.56	4 01	**13.21**[1]	-	87.24	61.23	85.51	91.01	**88.34**
00,	Old-process linseed meal,	6.97	36.75	8.21	39.80	8.27	**13.24**[1]	-	88.79	57.02	77.55	88.59	**83.99**
00,	Corn cobs,	1.92	3.86	27.17	65.77	1.28	**30.35**[1]	-	17.38	65.33	60.04	50.11	**63.12**
00,	Dried brewers' grains,	3.59	22.99	14.52	51.09	7.81	**23.77**[1]	-	79.26	52.57	57.83	91.11	**56.48**
00,	Spring wheat bran,	6.13	17.60	11.48	59.39	5.40	**28.22**[1]	-	79.63	23.59	70.38	75.60	**62.41**
00,	Winter wheat bran,	6.24	17.04	9.32	62.83	4.57	**23.95**[1]	-	78.54	56.28	70.43	60.54	**64.24**
0,	Atlas meal,	1.03	42.63	9.73	30.84	15.77	**12.76**[1]	-	72.80	105.70	84.45	91.24	**90.03**
0,	Peanut feed,	5.06	12 06	54.40	22.94	5.54	**20.69**[1]	-	70.56	11.68	49.05	89.68	**40.51**
0,	Soy bean meal,	6.20	38.47	4.50	31.94	18.89	**5.18**[1]	-	90.05	50.42	72.17	85.02	**64.43**

[1] These results were obtained by the phenylhydrazine method; the others, by the Krüger and Tollens phloroglucol method.

The results show that the pentosans comprise from one-tenth to nearly one-third of the entire feed stuff, the grains and by-products naturally containing the smaller and the coarse feeds the larger amounts.

The pentosans are found to be fully as digestible as the other fodder groups in case of upland hays and most by-products, but rather less digestible in swale hay, salt grasses and wheat bran. An explanation of this is to be found in the fact that association affects the digestibility of the pentosans. Late-cut hays, straws and bran contain considerable lignified matter, and it is this lignified or incrusting substance which exerts a negative influence upon the digestibility of all of the several fodder groups, the pentosans proving no exception. Most grains contain relatively small amounts of lignin and pentosans. Concentrated by-products, the residues of the several grains from which the starch, fat or both have been removed, contain higher pentosans percentages than the grains, for the reason that the pentosans are found largely in the external coverings, which are always more or less lignified. The pentosans, being closely associated with the lignified tissue, are in such cases less digestible than the protein, fat or total extract matter. In other cases (gluten feed), the incrusting substances being less developed, the pentosans have a digestibility nearly equal to the other groups.

Lehmann,[1] and later Kellner and Köhler,[2] have clearly shown that lignin interferes with the digestibility of the pentosans. The former subjected oat and wheat straws to the action of dilute sodium hydrate, under low pressure, for several hours, neutralizing with hydrochloric acid. After this treatment the pentosans in oat straw showed an increased digestibility of 69 per cent. and those in wheat straws of 115. Kellner, by a similar process, found the fibre and pentosans in extracted rye straw to be respectively 84.5 and 84.8 per cent. digested.

The experiments herein reported show that sheep were able to digest from 40 to 90 per cent. of the pentosans in grains and by-products. It has been held, however, that, although these quantities are removed from the digestive tract, it is by no means certain that they have a food value equal to starch and similar substances. Considerable quantities have been recognized in the urine of human beings. Weiske and Wicke,[1] as well as ourselves, have recognized only traces in the urine of sheep. It has been assumed that they may be destroyed in the digestive tract by various micro-organisms. Tollens[2] very pertinently suggested that they were no less susceptible to such destructive influences than is starch.

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[1] Landw. Jahrbücher 24. Jahrg., 1895; I Erganzungsband, p. 118.

[2] Landw. Versuchsstationen 53, p. 278.

It remained, however, for Kellner,[3] as a result of very exhaustive experiments with the aid of the respiration calorimeter, to furnish definite information. Oxen were fed a basal ration, to which were added at different times 2.5 kilograms of starch and 3 kilograms of rye straw, the latter previously extracted with dilute sodium hydrate under pressure. He found 2.32 per cent. of the carbon from the digested starch to be in the form of marsh gas (equivalent to a loss of 10.1 per cent. potential energy) ; and, from the extracted straw[4] digested, 3.34 per cent. of the carbon to be in the form of marsh gas (equal to a loss of 14 per cent. of potential energy). The differences were not marked. In general, the poorer the mechanical condition of the feed and the larger the amount of incrusting substance present, the longer it remains in the intestines and the greater the opportunity for micro-organisms to attack it ; and, *vice versa*, the more easily digested starchy matters, free from lignin, are more quickly resorbed and are less likely to undergo bacterial destruction. Kellner concluded that the furfural-yielding substances (pentosans) of the extracted straw took part in the formation of fat, and indirectly in the formation of flesh, to as great an extent as did either starch or cellulose.[5]

It may be safely concluded, therefore, that the pentosans are as digestible as any of the other fodder groups (except in the presence of excessive incrusting substance), and that the digested material is practically utilized in the animal organism to the same degree as the other carbohydrates.

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[1] Loco citato. [2] Journal f. Landw., 1897, p. 110. [3] Loco citato, pp. 426–428.

[4] This treated straw contained 82 per cent. of crude fibre, and over 30 per cent. of pentosans. [5] Loco citato, p. 457.

E. DIGESTION EXPERIMENTS WITH SHEEP.

J. B. LINDSEY.[1]

Digestion experiments were begun with sheep at this station in 1893. Two series were published in full in the eleventh and twelfth reports of the Massachusetts State Experiment Station, together with a description of the method employed (see eleventh report). Since 1894 the coefficients only of several series have been published in different reports of the Hatch Experiment Station. In the table which follows will be found the results of 185 single trials with 73 feed stuffs, being the entire number of experiments made between 1894 and 1902, excepting a few which gave results of uncertain value, and hence were discarded. The complete data for each experiment is on file at this station.

It is believed that the brief description of the various feeds found in the table will suffice in most instances to give a clear understanding as to their character. The following additional information may prove of value: —

Mixed grasses in the table includes Kentucky blue-grass, red-top, timothy, meadow fescue, sweet vernal grass, and alsike and red clover. Kentucky blue-grass and clover predominated.

English hay is a term commonly used in many localities for good upland hay, as distinct from salt and swale hays.

Gluten meal consists of the glutinous part of the corn, mixed with the starchy portion, that cannot be recovered by mechanical methods.

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[1] These experiments were made with the co-operation of a number of assistants. The results in the following table were compiled from the completed data by P. H. Smith.

Gluten feed includes the glutinous part of the corn (gluten meal), together with the corn bran and broken germs.

Germ oil meal consists of the ground corn germs, from which the oil has been partially pressed.

Distillers' grains are the dried residues in the process of manufacturing alcohol, spirits and whiskey from the several cereals.

H-O feeds consist of oat offals and light oats as a basis, together with some corn, and fortified with wheat bran and cotton-seed or gluten meal.

Quaker dairy feed — formerly Quaker oat feed — consists principally of oat offal, fortified with some material rich in protein.

Data of Digestion Experiments with Sheep, 1894–1902.

[The teachings from these experiments are presented from time to time in popular bulletins treating of feeds and feeding. — J. B. L.]

Series.	KIND AND AMOUNT OF FOOD A DAY.	Water Content as fed (Per Cent.).	COMPOSITION OF WATER-FREE SUBSTANCE.					Sheep Number.	DIGESTION COEFFICIENTS.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
I.,	English hay, "D," mixed grasses in bloom (taken from twelfth annual report, State Experiment Station).	-	7.63	9.74	32.97	47.25	2.41	-	55.00	-	58.00	57.00	57.00	47.00
II.,	English hay, "A," mostly *poa pratensis* in bloom, 900 gm.	7.15	5.83	7.47	36.41	47.90	2.39	1	54.90	-	53.52	56.34	55.73	41.54
								2	55.68	-	47.02	59.68	56.26	38.67
								3	57.83	-	56.25	59.60	58.85	44.42
								4	58.19	-	54.77	60.72	58.73	46.12
								Av.,	56.65	-	52.89	59.09	57.39	42.69
II.,	English hay, "B," mostly *poa pratensis* in bloom, 850 gm.	8.22	5.94	11.07	32.00	47.92	3.07	2	62.37	-	62.17	64.28	62.72	56.18
								4	65.30	-	62.86	69.76	65.38	51.27
								Av.,	63.84	-	62.52	67.02	64.05	53.72
III.,	English hay, "A," mostly *poa pratensis* in bloom, 900 gm.,	7.41	5.53	9.49	32.23	49.53	3.22	1	60.33	45.63	56.33	63.09	61.31	54.79
								2	58.43	49.45	59.78	57.11	60.52	50.57
								3	56.36	44.73	52.58	56.26	59.21	44.44
								4	59.26	46.34	57.18	60.17	60.95	50.99
								Av.,	58.60	46.54	56.47	59.16	60.50	50.20

III.,	English hay, "B," the same as III., "A,"	-	-	-	-	-	-	1	59.60	52.19	57.53	60.68	60.20	53.85
								5	63.18	48.45	62.47	65.90	63.54	57.63
								6	59.95	49.50	59.46	59.28	61.86	56.24
								Av.,	60.91	50.05	59.82	61.95	61.87	55.91
IV.,	English hay, "A," mostly *poa pratensis* in bloom, 900 gm.	11.54	6.34	10.04	32.67	48.53	2.42	1	61.52	43.80	59.48	66.00	61.90	48.11
								2	59.55	45.13	59.83	61.05	60.96	47.40
								3	62.61	47.94	63.09	64.77	63.69	48.27
								4	63.40	47.35	61.50	66.56	64.37	51.31
								5	63.13	45.92	61.69	66.05	64.36	50.03
								6	62.68	47.36	61.74	65.32	63.71	50.34
								Av.,	62.15	46.25	61.22	64.96	63.17	49.51
V.,	English hay, "A," mostly *poa pratensis* in bloom, 900 gm.	13.36	6.84	9.32	34.52	47.02	2.30	1	57.16	47.96	60.01	53.47	61.30	43.64
								2	60.15	47.95	62.22	59.00	62.85	48.51
								3	56.30	43.80	57.56	54.87	59.66	40.94
								4	57.33	52.59	61.39	53.69	60.22	49.33
								5	60.26	47.78	60.79	60.20	62.56	49.31
								6	60.11	49.45	62.16	59.60	62.08	50.94
								Av.,	58.63	48.26	60.76	56.81	61.45	47.11

Data of Digestion Experiments with Sheep, 1894-1902 — Continued.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance.					Sheep Number.	Digestion Coefficients.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
VI.,	English hay, "A," mostly *poa pratensis* in bloom, 900 gm.	14.46	6.01	10.49	33.43	47.10	2.97	1	63.30	48.78	65.16	62.75	65.54	56.75
								2	61.73	48.87	64.87	58.79	65.11	56.17
								3	63.85	47.73	64.57	63.67	66.29	58.01
								4	63.28	48.25	65.45	64.58	64.19	56.88
								5	62.47	47.23	64.69	63.67	63.22	60.04
								Av.,	62.93	48.11	64.95	62.69	64.87	57.57
VII.,	English hay, "A," the same as VI., "A," sampled a year later.	10.13	4.44	9.78	32.71	50.45	2.62	-	63.00	48.00	65.00	63.00	65.00	57.50
II.,	Timothy hay, 850 gm., ...	7.60	6.16	9.64	33.98	47.22	3.00	1	55.09	-	57.15	55.52	54.72	56.76
								2	55.87	-	50.65	59.16	55.85	58.24
								Av.,	55.48	-	53.91	57.34	55.29	57.50
IV.,	English hay, mixed grasses, late cut, 900 gm., . .	11.94	5.64	9.39	34.73	48.32	1.92	2	52.39	22.39	51.18	55.26	54.44	36.53
								3	53.54	29.57	56.66	56.71	53.97	40.73
								Av.,	52.96	25.98	53.92	55.98	54.20	38.63

IV.,	English hay, mixed grasses, late cut, 900 gm.,	9.95	5.40	9.57	33.98	48.98	2.07	1	56.92	38.53	54.29	61.17	56.89	46.73
								2	56.57	45.65	56.27	57.07	58.08	42.10
								Av.,	56.74	42.09	55.28	59.12	57.49	44.42
I.,	Black grass, *Juncus Gerardi* (fed with 450 gm. English hay, I., "D"), 450 gm.	22.66	11.67	9.51	26.80	49.54	2.48	3	56.69	-	62.47	56.80	53.40	37.31
								4	62.35	-	63.29	64.20	59.29	45.77
								Av.,	59.52	-	62.88	60.50	56.34	41.45
III.,	Black grass, *Juncus Gerardi*, rather damp and mouldy (fed with 400 gm. English hay, III., "A"), 500 gm.	16.44	7.87	8.71	28.71	52.23	2.48	2	50.06	70.95	52.62	50.43	46.64	41.40
								3	51.37	66.96	52.57	56.06	46.44	44.39
								4	58.82	69.00	57.68	65.55	54.04	51.35
								Av.,	53.42	68.97	54.29	57.35	49.04	45.71
I.,	Branch grass, *Distichlis spicata* (fed with 400 gm. English hay, I., "D"), 600 gm.	18.13	10.29	8.27	26.47	52.76	2.21	3	56.68	-	63.19	56.06	55.20	35.57
								4	54.52	-	61.34	48.45	52.37	27.39
								Av.,	55.60	-	62.26	52.25	53.78	31.48
III.,	Branch grass, *Distichlis spicata*, in poor condition (fed with 400 gm. English hay, III., "A"), 500 gm.	22.98	7.85	7.87	26.46	55.00	2.82	2	49.43	58.19	52.16	56.63	45.25	34.53
								3	50.08	60.30	50.97	56.33	46.54	33.24
								4	49.54	55.90	51.93	56.27	45.42	42.17
								Av.,	49.68	58.13	51.69	56.41	45.74	36.65
I.,	Fox grass, *Spartina patens* (fed with 450 gm. English hay, I., "D"), 450 gm.	14.30	8.14	7.48	26.41	55.46	2.51	3	50.63	-	62.83	45.55	51.85	42.25
								4	54.82	-	62.48	55.19	54.68	51.03
								Av.,	52.70	-	62.70	50.37	53.26	46.64

Data of Digestion Experiments with Sheep, 1894-1902 — Continued.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance.					Sheep Number.	Digestion Coefficients.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
I.,	Fox grass, *Spartina patens* (fed with 400 gm. English hay, I., "D"), 550 gm.	15.37	5.84	7.13	26.57	57.89	2.57	3	51.54	–	56.99	49.25	52.30	17.30
								4	54.11	–	57.41	53.39	51.20	30.26
								Av.,	52.80	–	57.00	51.30	51.50	23.80
III.,	Fox grass, *Spartina patens* (fed with 400 gm. English hay, III., "A"), 500 gm.	17.56	7.51	8.76	26.96	54.31	2.46	1	55.82	58.11	55.69	58.67	54.65	41.91
								2	52.94	59.31	61.19	53.64	51.28	31.26
								4	55.74	57.30	61.03	59.89	53.43	36.00
								Av.,	54.83	58.24	59.30	57.40	53.12	36.39
	Fox grass, *Spartina patens*, ...	–	–	–	–	–	–	–[1]	53.44	58.24	59.67	53.02	52.63	35.61
III.,	Salt hay, "cove mixture," black grass and red top (fed with 400 gm. English hay, III., "A"), 500 gm.	18.00	7.19	8.82	27.57	54.32	2.10	2	54.40	58.77	52.04	59.53	52.49	31.20
								3	52.57	57.17	46.49	56.92	51.16	48.03
								4	56.61	56.56	45.22	62.59	55.91	41.75
								Av.,	54.59	57.50	47.92	59.68	53.19	40.33

III.,	Salt hay mixture, fox and branch grasses, etc. (fed with 400 gm. English hay, III., "A") 500 gm.	16.00	9.98	6.48	26.77	54.26	2.51	2	52.18	67.83	42.32	53.91	50.57	30.18
								4	55.97	69.71	41.12	61.11	53.99	25.70
								Av.,	54.07	68.77	41.72	57.51	52.28	27.90
III.,	Red top hay, *Agrostis vulgaris*, bordering salt marsh, mixed with some sedge, over ripe (fed with 400 gm. English hay, III., "A"), 500 gm.	13.00	6.46	7.80	32.38	51.54	1.82	2	45.74	14.57	36.61	54.54	45.06	55.81
								3	45.94	9.19	36.75	54.62	46.37	47.13
								4	46.47	6.46	38.29	58.16	45.39	44.03
								Av.,	46.05	10.07	37.22	55.71	45.61	48.99
IV.,	Flat sage hay, *Spartina stricta maritima* var. (fed with 400 gm. English hay, IV., "A"), 500 gm.	17.00	9.79	7.82	29.71	49.77	2.91	2	55.39	61.41	50.70	59.75	53.67	32.67
								3	57.62	62.32	49.75	61.36	56.74	39.70
								4	56.55	62.15	54.86	60.16	54.75	36.06
								Av.,	56.52	61.96	51.77	60.42	55.05	36.14
I.,	Swale hay, fresh water grasses, sedges, brakes and wild flowers, 1,000 gm.	12.33	6.20	7.97	31.06	52.90	1.87	3	37.88	–	31.11	30.27	46.03	43.60
								4	39.89	–	36.66	35.66	45.99	43.61
								Av.,	38.88	–	33.88	32.97	46.01	43.60
V.,	Meadow fescue hay, *Festuca elatior pratensis*, early blossom, 900 gm.	12.73	6.60	7.33	37.89	45.96	2.22	2	60.29	46.49	53.29	66.79	58.49	53.05
								6	61.29	46.37	51.35	67.34	60.05	54.47
								Av.,	60.79	46.43	52.32	67.07	59.27	53.76

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[1] Average of 7 sheep.

Data of Digestion Experiments with Sheep, 1894–1902 — Continued.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance.					Sheep Number.	Digestion Coefficients.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter. (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
V.,	Tall oat grass hay, *Arrhenatherum elatius*, early blossom, 800 gm.	13.23	5.78	6.51	36.32	49.30	2.09	1	54.01	38.87	51.31	53.04	56.39	57.96
								6	56.56	43.40	50.53	56.67	59.00	53.62
								Av.,	55.27	41.14	50.92	54.86	57.69	55.79
VI.,	Tall oat grass hay, *Arrhenatherum elatius*, late blossom, 900 gm.	10.25	5.34	6.53	40.57	46.16	1.40	4	46.47	13.80	33.27	55.38	44.63	33.16
								5	50.02	25.15	38.08	59.58	46.54	37.29
								Av.,	48.25	19.48	35.69	57.48	45.59	35.23
VI.,	Canada blue grass hay, *Poa compressa*, in blossom, 900 gm.	10.75	5.65	6.86	36.40	48.87	2.22	1	61.97	40.91	42.96	69.94	62.22	38.13
								2	62.51	42.01	43.27	70.69	62.70	35.78
								Av.,	62.24	41.46	43.12	70.32	62.46	36.96
V.,	Kentucky blue grass hay, *Poa pratensis*, in blossom, 900 gm.	10.50	5.75	9.29	37.62	45.59	1.75	2	56.37	42.40	56.67	63.14	53.03	42.52
IV.,	Millet hay, *Panicum Italicum*, 800 gm., ...	12.52	6.34	4.66	35.98	51.38	1.64	3	51.81	15.73	32.08	60.17	52.42	47.72
								4	58.08	31.54	30.06	66.24	58.57	52.31
								Av.,	56.47	23.64	31.07	63.21	55.50	50.02

III.,	Barnyard millet, *Panicum crus-galli*, late blossom, fed green, 3,000 gm.	81.83	8.59	11.00	35.03	43.65	1.73	4	67.17	61.23	72.30	70.64	64.51	61.08
IV.,	Barnyard millet hay, late blossom, the same lot as preceding sample, (fed with 400 gm. English hay, IV., "A"), 500 gm.	12.67	10.18	10.73	34.48	43.05	1.56	1	57.10	62.99	63.69	59.82	52.26	44.18
								5	58.43	62.58	62.92	63.60	52.41	49.62
								6	56.88	63.89	64.39	61.36	50.07	45.21
								Av.,	57.50	63.15	63.67	61.59	51.58	46.34
VI.,	Barnyard millet, just heading out, fed green, 3,000 gm.,	83.36	8.77	10.18	33.60	45.48	1.97	1	67.08	50.94	61.22	71.57	68.71	54.83
								2	70.49	47.83	61.65	77.12	72.61	54.73
								3	67.44	45.09	58.11	73.18	70.19	53.91
								Av.,	68.34	47.95	60.33	73.96	70.50	54.49
VII.,	Barnyard millet hay, just heading out, the same lot as preceding sample, 900 gm.	12.33	9.04	10.24	36.38	42.88	1.46	1	58.75	50.58	56.37	66.42	54.84	49.39
								2	62.39	52.07	59.27	70.84	58.64	47.48
								Av.,	60.57	51.33	57.82	68.63	56.74	48.44
III.,	Barnyard millet, early blossom, fed green, 3,000 gm., .	81.12	7.84	8.44	32.06	49.92	1.74	2	71.51	64.79	66.59	70.94	74.10	61.39
								3	75.51	67.49	69.65	76.79	77.39	67.39
								Av.,	73.51	66.14	68.12	73.86	75.74	64.39
VI.,	Winter wheat and hairy or sand vetch hay (1½ — 1), 900 gm.	13.72	6.05	12.67	34.20	44.83	2.25	1	64.64	37.36	70.87	64.48	66.85	61.65
								2	64.18	35.70	71.89	63.09	66.71	63.07
								3	64.81	32.53	69.56	66.19	66.69	66.52
								Av.,	64.50	35.20	70.77	64.59	66.75	63.75

Data of Digestion Experiments with Sheep, 1894–1902 — Continued.

Series.	KIND AND AMOUNT OF FOOD A DAY.	Water Content as fed (Per Cent.).	COMPOSITION OF WATER FREE SUBSTANCE.					Sheep Number.	DIGESTION COEFFICIENTS.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
VI.,	Winter wheat and hairy or sand vetch (1 — 1) vetch predominating, in blossom, fed green, 3,000 gm.	83.52	9.04	19.58	30.88	37.59	2.91	1	68.51	46.46	77.21	66.85	71.59	56.37
								2	65.71	36.81	73.89	65.51	69.44	54.41
								3	68.40	44.15	77.71	65.80	72.37	57.47
								Av.,	67.54	42.47	76.27	66.05	71.13	55.65
VII.,	Winter wheat and hairy or sand vetch hay, the same lot as preceding sample, 900 gm.	11.90	9.05	19.38	32.21	36.91	2.45	1	67.90	59.63	76.04	64.21	69.24	61.61
								2	69.20	60.42	77.43	65.25	70.74	65.21
								3	67.89	58.19	77.12	63.94	69.15	63.56
								Av.,	68.33	59.41	76.86	64.47	69.71	63.46
VII.,	Winter wheat and hairy or sand vetch (1½ — 1), fed green (with 300 gm. English hay, VII., "A"), 2,000 gm.	79.57	8.63	15.38	29.34	43.73	2.92	3	68.78	42.23	68.86	69.72	73.71	54.48
								4	71.47	44.95	72.98	71.28	76.38	61.36
								Av.,	70.13	43.59	70.92	70.50	75.05	57.92
VI.,	Canada field peas, full blossom, fed green (with 300 gm. English hay, VI., "A"), 2,000 gm.	83.17	8.83	19.72	31.60	37.20	2.65	1	63.49	43.81	80.40	45.76	75.15	48.10
								2	64.88	40.24	79.26	52.44	74.31	53.36
								3	60.15	44.79	79.14	40.12	71.63	44.95
								Av.,	62.84	42.95	79.60	46.11	73.70	48.80

VII.,	Canada field peas, full blossom, fed green, 3,000 gm., .	86.19	8.81	21.31	28.09	38.48	3.31	1	63.59	32.63	81.49	44.58	75.08	58.42
								2	67.18	33.40	83.49	48.48	79.80	64.11
								3	61.14	26.38	79.75	39.69	74.83	56.89
								Av.,	63.97	30.80	81.58	44.25	76.57	59.81
VII.,	Hairy or sand vetch in blossom, fed green (with 300 gm. English hay, VI., " A "), 2,000 gm.	82.37	12.82	25.52	26.21	32.12	3.33	1	68.99	30.33	82.12	61.19	79.87	64.48
								2	72.51	28.65	81.40	70.37	84.13	68.99
								Av.,	70.75	29.49	81.76	65.78	82.00	66.74
III.,	Spring vetch and oats (1—1) in blossom, fed green, 3,000 gm.	83.10	8.70	12.78	35.48	40.34	2.70	2	67.17	54.81	75.96	67.85	67.76	47.63
								3	69.26	53.71	75.00	71.53	69.97	52.09
								4	64.70	49.45	73.33	65.47	65.98	41.93
								Av.,	67.04	52.66	74.76	68.28	67.90	47.22
III.,	Canada peas and oats (1—1), in blossom, fed green, 3,000 gm.	82.80	7.99	11.24	31.05	46.67	3.05	2	69.63	51.62	69.43	66.50	75.56	58.59
								3	72.01	51.20	73.21	70.32	77.12	61.19
								4	69.03	45.26	67.72	68.07	75.21	51.46
								Av.,	70.22	49.36	70.12	68.29	75.96	57.08
IV.,	Corn silage, Pride of the North corn, mature (fed with 400 gm. English hay, IV., " A "), 1,500 gm.	72.00	4.62	6.67	20.77	65.13	2.81	1	72.07	24.04	13.40[1]	73.44	80.90	72.05
								5	75.62	27.78	45.34	72.44	82.78	81.78
								Av.,	73.84	25.91	45.34	72.94	81.84	76.91

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[1] Omitted from average.

Data of Digestion Experiments with Sheep, 1894–1902 — Continued.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance.					Sheep Number.	Digestion Coefficients.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
II.,	Barnyard millet and medium green soy bean silage (fed with 400 gm. English hay, II., "A"), Sheep 1-2, 1,600 gm., Sheep 3-4, 1,800 gm.	81.67	10.55	12.01	36.07	37.12	4.25	1	54.40	-	58.13	57.47[1]	51.49[1]	75.93
								2	58.11	-	52.20	64.32	55.78	72.04
								3	57.95	-	41.79[1]	70.11	58.66	68.59
								4	64.75	-	61.94	73.89	63.29	80.00[1]
								Av.,	58.80	-	57.42	69.44	59.24	72.19
II.,	Corn and soy bean silage (2—1), Pride of the North corn and medium green soy bean (fed with 400 gm. English hay, II., "B"), 1,600 gm.	74.83	7.18	9.42	28.22	52.78	2.40	1	66.42	-	64.84	58.95	72.71	82.83
								2	68.62	-	63.07	64.74	74.31	79.81
								4	71.84	-	67.21	70.63	77.79	83.74
								Av.,	68.96	-	65.04	64.77	74.94	82.13
II.,	Cotton-seed feed, 4 parts hulls, 1 part meal, 850 gm.,	11.88	3.15	11.67	42.45	38.92	3.81	3	56.55	-	36.37	60.37	57.29	85.52
								4	57.57	-	41.86	57.33	59.75	92.65
								Av.,	57.06	-	39.12	58.85	58.52	89.09

III.,	Cotton-seed feed, 4 parts hulls, 1 part meal, 900 gm., .	11.79	3.73	12.21	37.83	42.16	4.07	1	54.74	34.68	42.17	50.89	59.84	93.78
								4	54.03	30.22	44.51	52.16	56.82	92.89
								Av.,	54.38	32.45	43.34	51.52	58.33	93.33
III.,	Cotton-seed feed, 4 parts hulls, 1 part meal (fed with 400 gm. English hay, III., "A"), the same lot as preceding sample, 500 gm.	12.24	-	-	-	-	-	2	57.74	23.52	41.23	59.99	59.84	98.38
								3	57.12	22.54	40.03	57.52	60.43	-
								Av.,	57.52	23.03	40.63	58.76	60.14	98.38
	Cotton-seed feed, average of six preceding tests, . .	-	-	-	-	-	-	-	56.29	27.74	41.03	56.38	58.99	92.64
V.,	Cleveland flax meal (fed with 700 gm. English hay, V., "A"), 150 gm.	10.46	5.82	40.37	9.88	41.32	2.61	1	85.21	23.28	84.05	-	93.98	53.25
								6	88.24	19.05	82.36	-	-	97.15
								Av.,	86.73	21.17	83.21	-	93.98	75.90
II.,	Pope cream gluten meal (fed with 700 gm. English hay, II., "A"), 150 gm.	8.20	.75	39.06	1.71	50.03	8.45	3	91.61	-	83.50	-	90.97	99.14
								4	94.89	-	84.00	-	95.35	-
								Av.,	93.25	-	83.75	-	93.16	99.14
II.,	Pope white gluten feed (fed with 600 gm. English hay, II., "A"), 250 gm.	9.24	1.36	27.92	6.72	55.79	8.21	3	85.90	-	84.52	75.61	90.36	82.02
								4	87.18	-	88.46	78.30	89.97	79.12
								Av.,	86.54	-	86.49	76.95	90.16	80.57
II.,	Buffalo gluten feed (fed with 600 gm. English hay, II., "A"), 250 gm.	8.42	.90	25.10	7.61	52.75	13.64	3	66.51	-	72.73	6.42	71.67	83.03
								4	69.25	-	74.80	11.65	72.56	85.62
								Av.,[2]	67.88	-	73.76	9.03	73.46	84.32

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[1] Omitted from average.

[2] Digestibility apparently much too low.

Data of Digestion Experiments with Sheep, 1894–1902 — Continued.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance.					Sheep Number.	Digestion Coefficients.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
III.,	Peoria gluten feed (fed with 600 gm. English hay, III., "B"), 200 gm.	8.53	1.02	22.72	7.15	63.03	6.08	1	93.61	–	84.59	99.77	97.81	89.00
								5	92.76	–	86.39	–	95.71	88.01
								6	87.64	–	82.79	84.94	92.93	83.77
								Av.,	91.34	–	84.59	92.35	95.48	87.59
VI.,	Germ oil meal (fed with 700 gm. English hay, V., "A"), 250 gm.	8.69	3.50	24.72	10.53	49.07	12.18	2	77.05	–	65.33	94.90	89.73	97.66
								3	82.59	–	72.89	–	83.58	95.46
								Av.,	79.82	–	69.11	94.90	86.66	96.66
V.,	Biles distiller's grain, brand R (fed with 600 gm. English hay, V., "A"), 250 gm.	8.80	2.18	17.93	13.69	60.11	6.09	5	55.61	–	56.29	–	61.09	80.06
								6	58.57	–	62.57	–	73.46	88.46
								Av.,	57.59	–	59.43	–[1]	67.28	84.26
V.,	Biles distiller's grain, brand X. (fed with 650 gm. English hay, V., "A"), 200 gm.	8.91	1.84	32.00	10.52	43.95	11.69	1	86.50	–	65.51	–	93.12	93.94
								3	87.07	–	80.05	–	85.15	97.60
								Av.,	86.78	–	72.78	–[1]	89.14	95.77

V.,	Biles distiller's grain, brand XX. (fed with 600 gm. English hay, V., "A"), 250 gm.	9.53	2.70	28.17	12.40	46.21	10.52	1	88.53	–	79.94	–	88.22	94.45
								6	79.77	–	76.50	–	79.77	94.87
								Av.,	84.15	–	77.22	–[1]	84.00	94.66
V.,	Biles distiller's grain, brand XXX. (fed with 600 gm. English hay, V., "A"), 250 gm.	7.46	2.22	32.27	11.11	41.62	12.78	2	79.88	–	73.41	–	78.03	91.78
								6	71.41	–	74.01	–	72.69	93.95
								Av.,	75.65	–	73.71	–[1]	75.36	92.87
V.,	Biles distiller's grain, brand XXXX. (fed with 600 gm. English hay, V., "A"), 250 gm.	8.83	1.86	38.13	12.50	36.74	10.77	1	79.82	–	72.08	–	81.12	96.99
								6	73.47	–	69.22	–	76.73	98.45
								Av.,	76.65	–	70.65	–[1]	78.93	97.70
IV.,	H-O dairy feed (fed with 650 gm. English hay, IV., "A"), 250 gm.	8.20	4.01	19.62	13.84	57.66	4.87	2	63.70	–	75.99	42.98	67.16	88.10
								3	66.84	–	79.64	38.69	72.61	82.83
								Av.,	65.27	–	77.82	40.84	69.89	85.47
VII.,	H-O dairy feed (fed with 650 gm. English hay, VII., "A"), 250 gm.	8.71	4.09	20.37	14.02	56.37	5.15	1	64.65	–	77.50	16.62	75.19	84.43
								2	64.82	–	67.93	41.75	73.99	83.23
								Av.,	64.74	–	72.72	29.19	74.59	83.83
IV.,	H-O horse feed (fed with 650 gm. English hay, IV., "A"), 250 gm.	9.79	3.42	14.33	10.92	67.16	4.17	2	63.46	–	61.20	8.32	76.17	81.17
								3	70.10	–	74.38	35.16	78.70	84.04
								Av.,[2]	–	–	–	–	–	–

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[1] The digestibility of fibre varied so much that coefficients are omitted.

[2] The results taken of Sheep 3 only.

Data of Digestion Experiments with Sheep, 1894–1902 — Continued.

Series.	Kind and Amount of Food a Day.	Water Content as fed (Per Cent.).	Composition of Water-free Substance.					Sheep Number.	Digestion Coefficients.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
VII.,	H-O horse feed (fed with 600 gm. English hay, VII., "A"), 300 gm.	11.20	3.57	13.39	10.32	68.53	4.19	2	74.40	–	64.90	52.34	84.88	78.49
								3	74.74	–	61.99	58.97	84.16	77.06
								Av.,	74.57	–	63.45	55.66	84.52	77.78
IV.,	Quaker oat feed (fed with 600 gm. English hay, IV., "A"), 300 gm.	7.41	5.39	11.97	19.02	59.67	3.95	1	63.30	–	82.35	44.05	68.14	91.52
								5	63.51	–	84.18	43.00	69.85	88.15
								6	59.04	–	76.87	40.66	64.27	87.24
								Av.,	61.95	–	81.10	42.57	67.42	88.97
VII.,	Quaker dairy feed (fed with 650 gm. English hay, VII., "A"), 250 gm.	8.62	5.06	15.07	17.27	58.84	3.76	1	64.08	–	69.07	56.45	70.50	75.67
								2	57.99	–	61.72	53.69	71.23	80.09
								Av.,	61.04	–	65.40	55.07	70.87	77.88
IV.,	Victor corn and oat feed (fed with 600 gm. English hay, IV., "A"), 300 gm.	9.56	3.75	10.21	12.42	69.44	4.18	1	73.75	–	65.70	35.90	84.89	84.39
								5	74.01	–	71.40	51.72	81.19	88.36
								6	76.45	–	75.41	57.75	82.76	87.74
								Av.,	74.74	–	70.84	48.46	82.95	86.83

V.,	Rye feed, bran and fine middlings (fed with 650 gm. English hay, V., "A"), 250 gm.	12.88	3.17	13.83	3.67	76.33	3.00	4	78.56	30.68	80.71	-	85.68	79.33
								5	84.91	48.19	82.14	-	89.27	90.81
								6	82.73	24.74	77.98	-	88.68	99.08
								Av.,	82.07	34.54	80.28	-	87.88	89.74
II.,	Rice meal (fed with 600 gm. English hay, II., "A"), 200 gm.	10.39	8.57	13.53	5.62	57.81	14.47	1	71.47	-	61.85	-	89.23	90.66
								2	76.19	-	37.36[1]	-	95.28	91.56
								Av.,	73.83	-	61.85	-	92.25	91.11
V.,	Chop feed, hulls bran and broken germs of maize (fed with 650 gm. English hay, V., "A"), 250 gm.	11.08	.93	12.10	14.06	66.75	6.16	1	71.30	-	64.02	58.83	75.56	86.41
								2	92.29	27.54	76.77	-	92.07	85.46
								3	77.47	-	62.64	70.12	82.96	75.60
								Av.,	80.35	27.54	67.81	64.48	83.53	82.49
III.,	Cerealine feed (fed with 600 gm. English hay, III., "A," and 100 gm. Chicago gluten meal), 150 gm.	12.10	2.53	10.85	5.00	74.03	7.59	1	89.59	-	69.69	-	92.62	77.54
								5	92.24	-	79.41	92.41	96.36	83.23
								6	89.39	-	80.59	72.08	96.88	80.94
								Av.,	90.39	-	80.00	82.24	95.29	80.57
VI.,	Corn bran (fed with 500 gm. English hay, VI., "A"), 400 gm.	16.56	1.52	10.27	14.80	68.60	4.81	4	69.87	-	55.22	64.68	74.06	80.25
								5	71.44	-	55.48	64.64	75.82	85.17
								Av.,	70.66	-	55.35	64.66	74.94	82.71

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[1] Omitted from average.

Data of Digestion Experiments with Sheep, 1894–1902 — Concluded.

Series.	KIND AND AMOUNT OF FOOD A DAY.	Water Content as fed (Per Cent.).	COMPOSITION OF WATER-FREE SUBSTANCE.					Sheep Number.	DIGESTION COEFFICIENTS.					
			Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).		Dry Matter (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per Cent.).
V.,	Parson's $6 feed, grain hulls and mill sweepings (fed with 600 gm. English hay, V., "A"), 300 gm.	11.22	8.88	11.23	20.10	57.41	2.38	1	56.37	13.88	61.96	49.55	62.54	81.07
								3	55.12	10.49	56.23	44.66	64.88	80.00
								Av.,	55.75	12.19	59.09	47.11	63.71	80.54
V.,	Oat feed, inferior (fed with 600 gm. English hay, V., "A"), 250 gm.	9.89	6.23	5.60	30.27	56.30	1.60	1	29.32	9.75	65.29	24.67	29.16	96.94
								2	38.22	20.72	69.26	37.47	35.81	88.89
								3	34.78	8.12	50.95	34.50	35.24	89.17
								Av.,	34.11	12.86	61.83	32.21	33.40	91.67

INFLUENCE OF DRYING AND CURING ON DIGESTIBILITY.

Jordan[1] summarized the results of six experiments made to throw light on this point, and states that in only two cases (clover and corn fodder) was there any decrease in digestibility due to drying. Experiments were made at this station with wheat and vetch and barnyard millet, and the results are found in the above tables. It will be seen that in case of the wheat and sand vetch no important difference was noted as a result of the curing process, while in both experiments drying noticeably decreased the digestibility of barnyard millet. Generally speaking, the mere withdrawal of the water is not supposed to affect digestibility, and this is likely to be especially true with young and tender plants and with the finer grasses. In the case of plants with coarse, tough stems, the reverse is likely to be true. The hardening of the woody stems in the curing process and the less perfect mastication resulting, as well as possible chemical and physiological changes, are all factors which may cause lessened digestibility.

Digestion experiments enable the investigator to form a reasonably correct opinion concerning the nutritive and economic value of the different coarse and concentrated feeds. The results of these experiments are presented from time to time in popular bulletins treating of feed and feeding.

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[1] Bulletin No. 77, U. S. Department of Agriculture: The Digestibility of American Feeding Stuffs.

REPORT OF THE AGRICULTURISTS.

WM. P. BROOKS; ASSISTANT, H. M. THOMSON.

The work of the agricultural division of the Experiment Station has followed the general lines of earlier years. It has for its chief object to obtain light on some of the numerous conditions determining productiveness, chiefly as affected by different manures and fertilizers used alone and in a wide variety of combinations. The questions connected with the use of manures and fertilizers are self-evidently of vital importance in our agriculture, which cannot, as in some of the newer States of the Union, depend upon the accumulated fertility of ages. Equally self-evident to every intelligent mind must be the fact that the solution of even the simplest problem connected with the use of manures is a matter of much inherent difficulty, so numerous are the conditions which determine production, — conditions, too, many of which are beyond control. It is clearly perceived that much caution should be exercised in drawing conclusions from the results of experiments; that field results especially should be tested again and again, under varying conditions of soil and season; that such results obtained on plots inevitably varying somewhat in natural fertility should be checked by results obtained on equal quantities of thoroughly mixed soils from the same plots under conditions made as nearly normal as possible; as well as by vegetation experiments in plots, where all the conditions of moisture, — exposure, etc., are most perfectly under control. Our work, therefore along these lines includes three distinct methods of experiment: first, plot experiments in the open field; second, closed plot experiments (plunged cylinders) with mixed soil; and third, vegetation experiments in pots.

In connection with lines of inquiry pertaining to the use of manures and fertilizers and in the other lines of work mentioned below we have cared for 251 plots upon our own grounds and have supervised work upon 20 plots in different parts of the State. In our experiments with mixed soil in enclosed plots (plunged cylinders) we have employed 153 cylinders. In our vegetation experiments we have cared for 278 pots.

Variety tests also have received considerable attention. The test with corn, which has included 31 varieties, will not be reported, as the grain is not yet dry enough to shell. We have had under careful observation some 70 species of grasses and forage crops, in addition to 18 varieties of millets. In connection with the grasses we are endeavoring to gain some light as to the relative value of the different kinds for pastures as well as for mowings by lawn-mowing one-half of each plot. We have obtained some striking results, but these will not be reported until we have carried the test further. The work with poultry has been for the most part along the lines which have engaged our attention in previous years, viz., a study of the best methods of feeding for eggs. In connection with our poultry work we are making comparative trials of various types of incubators and brooders, which are being used in raising the fowls we use in our feeding experiments. We are also making careful records touching the food cost of raising chickens.

In this report we shall discuss briefly the results obtained in a portion only of the plot experiments pertaining to the use of manures and fertilizers, selecting for this purpose the results which are confirmed by the greatest number of years' work, as well as in many cases by the closed plot and pot experiments. We shall report also the results of the variety test with potatoes, and shall make a brief statement touching the results obtained in experiments with poultry. The nature of the subjects of inquiry and the more important features of our results will be made clear by the following statement: —

I. — To determine the relative value of barnyard manure, nitrate of soda, sulfate of ammonia, and dried blood as sources of nitrogen. The crop of this year, potatoes, gives yields on the basis of which the materials rank in the following order: dried blood, sulfate of ammonia, barnyard manure, nitrate of soda. The yield on the last two is, however, below the yield on the plots receiving no nitrogen, and the results are complicated by the fact that the crop suffered from blight and rot. The average to date ranks the materials in the following order: nitrate of soda, barnyard manure, sulfate of ammonia, and dried blood.

II. — To determine to what extent, if any, the introduction of a crop of the clover family will make the application of nitrogen to the following crop unnecessary. Potatoes this year followed soy beans, and gave a yield on the no-nitrogen plots equivalent to 99.3 per cent. of that obtained on the plots to which nitrogen has been yearly applied.

III. — To determine the relative value of muriate and high-grade sulfate of potash for field crops. The results of the year indicate sulfate to be superior to the muriate for cabbages, mixed timothy and clover, and potatoes as indicated by the yield of merchantable tubers. The results with onions were indecisive as the crop failed to mature, largely, it is believed, on account of the cold summer.

IV. — *A.* To determine the relative value of nitrate of soda, sulfate of ammonia, and dried blood, used in connection with manure as sources of nitrogen for garden crops. The results indicate these materials used in amounts furnishing equal nitrogen to rank in the following order: nitrate of soda, dried blood, sulfate of ammonia. *B.* To determine the relative value of sulfate and muriate of potash for garden crops. The results of the year indicate the sulfate of potash to be the better for onions, tomatoes and celery; while the muriate has given slightly superior results with strawberries and squashes.

V. — To determine the relative value of different potash salts for field crops. The salts under comparison are high-grade sulfate, low-grade sulfate, kainite, muriate, nitrate, carbonate, and silicate. The crop of this year was clover. The potash salts giving the best yields are the silicate, high-grade sulfate, and nitrate. The most striking result brought out is the injury to young clover in a cold, wet spring, due to potash salts containing chlorine, especially to the kainite.

VI. — To determine the relative value of phosphates used in quantities furnishing equal phosphoric acid to each plot. The crop of this year was onions; and the phosphates giving the best results, and the only ones which can be considered even fairly satisfactory, in the order of their rank, are: dissolved bone meal, fine-ground raw bone, phosphatic slag, and the steamed bone meal. Two gave results very much inferior to all others, viz., Tennessee phosphate and Florida soft phosphate.

VII. — *A.* Soil test with corn. The results of this year indicate that potash to a far greater extent than any other plant-food element controls the yield of corn. Muriate of potash alone at the rate of 160 pounds per acre annually for fourteen years gives this year a yield at the rate of 47.7 bushels of shelled grain per acre. The combination of dissolved bone-black with the same amount of muriate of potash gives a crop of 55.9 bushels of shelled grain per acre. *B.* Soil test with potatoes. The results of the year indicate that the muriate of potash on the limed portion of the field increased the crop more than either of the other fertilizer elements; but the potato crop is increased to a considerably greater extent by the use of materials furnishing phosphoric acid and nitrogen than was the corn in the other soil test.

VIII. — To determine the relative value for the production of corn and mixed grass and clover in rotation of a large application of manure, as compared with a smaller application of manure in connection with a potash salt. The crop of this year was mixed grass and clover. The manure alone gave crops somewhat larger than the combined manure and potash, but, owing to the lesser cost of the combination, the financial result is in its favor.

IX. — To determine the relative value for crop production of two fertilizer mixtures, one furnishing the important elements of plant food in the same proportion in which they are found in the average of corn fertilizers offered in our markets, the other containing less phosphoric acid and more potash, the crops being corn and mixed grass and clover in rotation. The crop of this year was mixed grass and clover. The result is a yield at the rate of 1,520 pounds per acre more on the fertilizer mixture containing the greater amount of potash; and this superior crop is produced at a cost per acre for fertilizers of about $4 less than the combination of materials used on the other plots. The nutritive value of the hay from the plots receiving the greater amount of potash is superior to that from the other plots, on account of the greater relative abundance of clover.

X. — To determine the economic result of using in rotation on grass lands: the first year, wood ashes and nitrate of soda; the second year, ground bone, muriate of potash, and nitrate of soda; and the third year, barnyard manure. The yields amount on the average to about 2 tons per acre, produced at a cost for manure and fertilizers making their application decidedly profitable.

XI. — To determine which is the better practice, — to spread fresh manure directly on the field during late autumn or winter, or to put into large piles in the field at the same time, these piles to be spread and immediately ploughed in in the spring. The field where this experiment is tried has a moderate slope. The crop of this year was corn, and the results were on the whole quite favorable to the spring application, although the difference in the yield this year was not sufficient to repay the cost of the extra handling.

XII. — To determine whether the use of nitrate of soda for rowen is profitable. The application of nitrate to a timothy sod at rates varying from 150 to 250 pounds per acre gives a marked increase in every case, — an increase more than sufficient to cover the cost of nitrate and its application.

XIII. — Variety test with potatoes. The varieties giving yields exceeding 250 bushels of merchantable tubers per acre, mentioned in the order of productiveness, are: Beauty of Hebron (first generation from Maine seed), Beauty of Hebron (second generation from Maine seed), I. X. L., Steuben, Early Nancy, Million Dollar, Ensign Bagley, Early Rose, Gem of Aroostook, and Daughter of Early Rose. It is significant that the old variety — the Beauty of Hebron — outranks all other varieties; while the still older Early Rose is exceeded by only 6 out of the 31 varieties.

XIV. — To determine the best nutritive ration in feeding hens for eggs. The results of the year appear to indicate that if materials carrying considerable fat are used in combination with rations in which wheat and corn respectively are most prominent, the wheat slightly surpasses the corn; but that if fat be not freely supplied in connection with such rations, the corn is superior to wheat. Corn and buckwheat compared, without materials furnishing any considerable amount of fat, give results markedly favorable to corn.

I. — THE RELATIVE VALUE OF MANURES FURNISHING NITROGEN. (FIELD A.)

A full description of the plan of the experiment in this field will be found in the twelfth annual report. The object is to determine the relative value for various crops of a few of the standard materials which may be used on the farm as a source of nitrogen. The materials under comparison are barnyard manure, nitrate of soda, sulfate of ammonia, and dried blood. These wherever used are applied in such quantity as to furnish equal amounts of nitrogen. To three plots in the field no nitrogen in any form has been applied. All the plots in the field receive the same amounts of materials furnishing phosphoric acid and potash and in liberal quantities. Barnyard manure is the source of nitrogen on one plot, nitrate of soda on two plots, sulfate of ammonia on three plots, and dried blood on two. This experiment was begun in 1890, and the crops which have been grown previous to this year in the order of succession are: oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover, potatoes, and soy beans. As the result of all experiments previous to this year, it is found that the materials furnishing nitrogen have produced crops ranking in the following order: —

	Per Cent.
Nitrate of soda,	100.0
Barnyard manure,	91.8
Sulfate of ammonia,	90.0
Dried blood,	87.7
The plots receiving no nitrogen,	71.0

The crop for this year was potatoes, which therefore follow a leguminous crop, — the soy bean. After the beans were harvested rye was sown as a cover crop, but the season of sowing was so late that it had made but little growth when the land was ploughed for potatoes this spring. The variety of potatoes grown was Beauty of Hebron. The seed stock used was grown in northern Maine. On April 10 it was treated in the customary way in solution of corrosive sublimate for prevention of scab. The seed was then spread in a single layer in a sunny room, where it remained until May 5. The seed stock was of excellent quality, the tubers in general smooth and of good size. Before planting they were cut to pieces of two good eyes each. They were planted in rows 3 feet apart and 1 foot apart in the rows. It is a matter of regret that the stock of seed reserved for this field proved not quite sufficient. Plots 0 to 2 and a part of 3 were planted with seed also grown in Maine, of the White Maine variety. This also was treated with corrosive sublimate solution, and before planting cut to pieces of two eyes. It was not, however, budded before planting. Growth throughout the early part of the season was normal and good. The crop was sprayed four times with Bowker's Boxal, which, as in other experiments, proved effective in destroying bugs, but did not entirely prevent blight. The dates of spraying were June 19 and 28, and July 11 and 26. Much care was taken in spraying, and it is believed that the fact that blight was not entirely prevented was due to the use of nozzles which threw the spray only on the upper surfaces of the leaves. Blight was quite general, although only just beginning, on August 12. By August 27 the tops were nearly all dead, except that a few scattering plants were still green at the tips on plots 0, 1, 2 and 3, and that the top leaves of the plants were generally green on plots 5, 6 and 8. The last three plots are those, as will be seen by the table below, to which sulfate of ammonia was applied; and it seems likely that this longer persistence of life in the tops was connected with the retarded growth due to the fact that the nitrogen of the sulfate of ammonia probably became available relatively late in the season. Digging the crop was commenced on August 29 and finished September 6. Those plots were dug first on which it was believed there was most decay. Some rotten tubers were found on all plots, those affected being generally of large size. The amount of rot, so far as can be judged, does not appear to have been affected by the nature of the fertilizers used, for we find very wide variations between plots all of which were similarly manured. The fertilizer treatment and the yields on the several plots are shown in the following table: —

Yield of Potatoes per Acre (Bushels).

Plots.	NITROGEN FERTILIZER.	Merchantable.	Small.	Rotten.
0	Barnyard manure,	132.00	19.50	16.33
1	Nitrate of soda,	119.67	15.50	8.33
2	Nitrate of soda,	104.17	18.67	21.67
3	Dried blood,	136.17	24.50	27.17
4	No nitrogen,	93.33	42.50	32.67
5	Sulfate of ammonia,	129.83	35.67	1.50
6	Sulfate of ammonia,	153.83	34.67	14.50
7	No nitrogen,	116.33	50.17	19.17
8	Sulfate of ammonia,	102.00	34.00	27.00
9	No nitrogen,	119.67	40.00	9.17
10	Dried blood,	157.67	32.83	37.67

The average results are as follows: —

FERTILIZER.	Merchantable (Bushels).	Small (Bushels).	Rotten (Bushels).
Average of the no-nitrogen plots (3),	109.78	44.22	20.34
Nitrate of soda plots (2),	111.92	17.09	15.00
Dried blood plots (2),	146.92	28.67	32.42
Sulfate of ammonia plots (3),	128.55	34.78	17.89

The relative standing of the different materials furnishing nitrogen, calling the one giving the largest yield 100, is as follows: —

	Per Cent.
Dried blood,	100.00
Sulfate of ammonia,	87.10
Barnyard manure,	80.68
Nitrate of soda,	69.22
No nitrogen,	83.80

The nitrate of soda stands relatively much lower than in previous experiments on this field. The past season was exceptionally rainy, and there may have been some loss of the nitrate, all of which was applied just before planting. Such loss would not, however, account for the fact that the yield on the nitrate is below that on the no-nitrogen plots; and we are compelled to conclude that the fact that normal development and ripening were interfered with by the prevalence of blight and rot has prevented the several fertilizers from exerting a full normal effect. In estimating the significance of the results, we must not, however, lose sight of the fact that the crop of last year was a legume (the soy bean), and that the great abundance of nodules upon its roots indicated that it developed under conditions making possible a very large assimilation of atmospheric nitrogen.

II. — CROPS OF THE CLOVER FAMILY (LEGUMES) AS NITROGEN GATHERERS.

This experiment is carried out in connection with experiments to determine the relative value of different materials furnishing nitrogen on Field A. Both soy beans and clover have been used previous to the present season, the former during three years and the latter for one year. The crop of both is harvested. Our object is to test, not the effect of ploughing under these crops, but simply the improvement following the introduction of each derived from their roots and stubble. Previous to the present year the results have indicated little or no improvement in the condition of the soil following the culture of the soy bean, and a very great improvement followed the turning under of the clover sod, as shown by the fact that the potato crop of 1900 grown upon the clover sod was almost as good where no nitrogen fertilizers have been used for eleven years as it was where such fertilizer has been annually used in fairly liberal amounts. The crop in 1901 was soy beans. For the present season it was potatoes. The average yields for this year as well as for the previous years during which the experiment has continued are shown by the table: —

Effect of Leguminous Crops upon the Following Crop (Pounds).

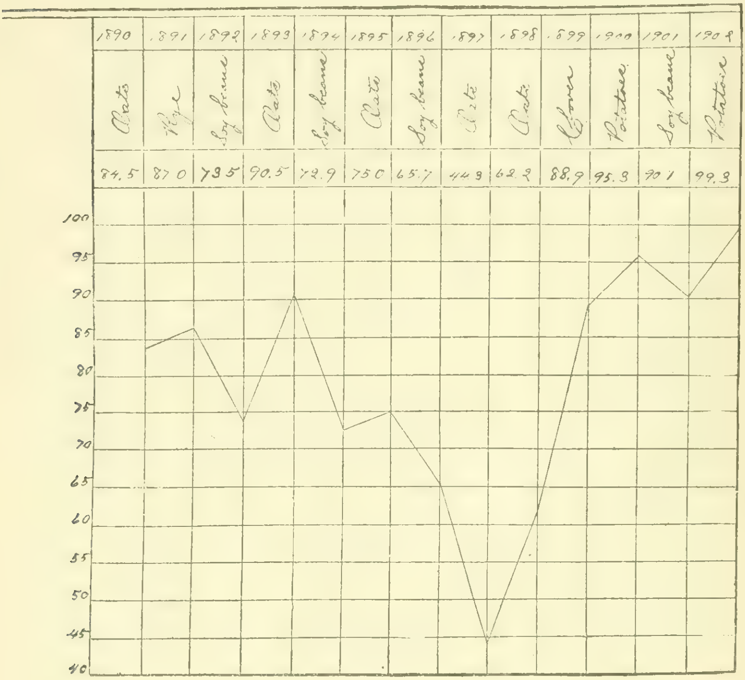
PLOTS (EACH ONE-TENTH).	1890.	1891.	1892.	1893.	1894.	1895.	1896.
	Oats.	Rye.	Soy Bean.	Oats.	Soy Bean.	Oats.	Soy Bean.
Nitrogen plots, ...	343	484	1,965	598	620	494	1,740
No-nitrogen plots, . . .	290	421	1,443	540	452	370	1,143

Effect of Leguminous Crops upon the Following Crop (Pounds) — Concluded.

PLOTS (EACH ONE-TENTH).	1897.	1898.	1899.	1900.	1901.	1902.
	Oats.	Oats.	Clover.	Potatoes.	Soy Bean.	Potatoes.
Nitrogen plots, ...	445	254	413	1,316	442.2[1]	1,053.6
No-nitrogen plots, ...	197	158	367	1,254	398.3[1]	1,046.0

[1] Dry beans and straw.

There are three plots in the field which have received neither manure nor fertilizer supplying nitrogen since 1884, and the figures showing yields are the averages for these plots. The figures for the nitrogen plots show the average products of the eight plots in the field which have yearly received an application of materials furnishing nitrogen in fairly liberal amounts. These materials are as follows: barnyard manure, one plot; nitrate of soda, two plots; sulfate of ammonia, three plots; and dried blood, two plots. At the rates at which they are used, these materials furnish 45 pounds of nitrogen per acre, and they are so used that each plot receiving a nitrogen fertilizer receives annually the same number of pounds of nitrogen. The past season is the eighteenth since the no-nitrogen plots have been manured with anything containing nitrogen. The curve below shows the per cent. which the yield on these plots constitutes of the yield on the plots manured with nitrogen.



That the crop of potatoes on the no-nitrogen plots this year amounts to 99.3 per cent. of the crop on the plots receiving nitrogen is a fact of much significance. In the earlier years of this experiment, as has been stated, the crops following soy beans have not appeared to derive any considerable benefit from the roots and stubble of this crop. For this year it is believed that we must conclude the benefit is considerable. This difference in the after-effect of the soy beans is possibly explained in part by the fact that the bacteria, whose presence is essential to the acquisition of atmospheric nitrogen, are now more abundant in this soil than during the earlier years when soy beans were grown;

but it may be that the relative standing of the no-nitrogen plots is higher than it would have been had the crop of potatoes grown to normal maturity. It will be remembered that blight and rot prevailed to a considerable extent, and these would naturally injure the potatoes with the ranker growth more than those where the growth was less luxuriant. It does not seem, therefore, that we are justified in concluding that the after-effect of the soy beans is as useful as the relation between the figures appears to indicate.

III. — THE RELATIVE VALUE OF MURIATE AND HIGH-GRADE SULFATE OF POTASH. (FIELD B.)

The object of this experiment, which has been in progress since 1892, is to determine the relative value for different crops of the two leading and cheapest sources of potash, viz., muriate and high-grade sulfate. These salts are used in equal quantities continuously upon the same land. The field contains eleven plots, of approximately one-eighth of an acre each. Of these, six have been yearly manured with muriate of potash and five with the high-grade sulfate. From 1892 to 1899 inclusive these salts were used at the rate of 400 pounds per acre; since 1900 the rate of application has been 250 pounds per acre. Fine-ground bone at the rate of 600 pounds per acre has been yearly applied to all plots. Various crops have been grown in rotation, including potatoes, field corn, sweet corn, grasses, oats and vetch, barley and vetch, winter rye, clovers of various kinds, sugar beets, soy beans, and cabbages. Most of these crops have been grown during several different years. All have with few exceptions given uniformly large yields. The results to date may be summarized as follows: among the crops grown, the potatoes, clovers, cabbages, and soy beans have usually done much the best on the sulfate of potash; the yield of corn, grasses, oats, barley, vetches and sugar beets has been about equally good on the two salts; the quality of the potatoes and sugar beets produced on the sulfate of potash plots has been distinctly better than that of the crops produced on the muriate of potash.

The crops of the past year have been mixed timothy and clover, cabbages, potatoes, and onions.

1. *Timothy and Clover* (*Sulfate v. Muriate of Potash*).

Mixed timothy and clover occupied two plots which were seeded in July, 1901. The proportion of clover on the sulfate of potash plot was distinctly greater than on the other. The variety of clover was the alsike. The yields are shown in the table: —

Muriate v. High-grade Sulfate of Potash. — Timothy and Clover Hay per Acre (*Pounds*).

	Muriate of Potash.	High-grade Sulfate of Potash.
Hay,	4,710	4,725
Rowen,	1,745	1,997
Totals,	6,455	6,722

It will be seen that there is no considerable difference in the amount of hay yielded by the two potash salts. The first crop, indeed, in which of course timothy was relatively abundant, was practically equal upon the two. There is more difference in the rowen crops, which is without doubt a consequence of the better growth of the clover (which furnishes most of the rowen) on the sulfate of potash. Our results, then, are confirmatory of those in previous years, which have tended to show that, especially in cool and wet seasons, clover does better upon sulfate than upon muriate of potash. The experiment of the present season upon another of our fields (Field G), to be reported later, is also strikingly confirmatory of this general principle.

2. *Cabbages.*

Cabbages occupied two plots (17 and 18) on which clover was grown last year; and a considerable growth of mixed white and alsike clover, with some sorrel and weeds, was ploughed in a few days before planting the cabbages. The variety of cabbage grown was the All Seasons, from Gregory & Son, Marblehead. The seed was planted in hills 3 by 2½ feet apart on June 16. A very heavy shower interrupted the work, and so packed the soil on the muriate of potash plot, where the planting had been completed, that germination was imperfect; while on the other plot, where the seed was put in after the shower, the stand of plants was good. When the plants were finally thinned and vacancies filled, it was found necessary to use some plants from the sulfate of potash plot to fill vacancies on the other plot. The summer proved so cool that the crop did not fully mature on either plot, as growth was unusually slow. The yields are shown in the table: —

Muriate v. High-grade Sulfate of Potash. — Cabbages, Yields per Acre.

	Muriate of Potash.	High-grade Sulfate of Potash.
Hard heads (number),	2,648	3,420
Hard heads (pounds),	26,063	35,550
Soft heads (pounds),	22,650	18,263

It will be noticed that the total yield of hard heads on the sulfate of potash was materially greater than on the other plot. The merchantable value of the hard heads on the two plots, at ½ cent per pound was, respectively, for the muriate of potash $130.32, for the sulfate $177.75; the sulfate, therefore, gave a crop worth $47.43 per acre more than the muriate. The sulfate in the quantity used cost less than 70 cents per acre more than the muriate. The result of this year is in exact agreement with the result obtained in 1899, when, as this year, the season was rather cold and rainy. When the seasons are hot and relatively dry, the difference between the two salts is comparatively small, and sometimes the muriate gives a slightly better crop than the sulfate. It seems evident, however, that on all except the lightest soils the sulfate is the safer of the two potash salts to employ for the cabbage crop.

3. *Potatoes (Sulfate v. Muriate of Potash).*

The potatoes grown in this experiment occupied two plots, 15 and 16. For the two preceding years these plots had been in clover, the clover sod being turned on April 15.

The variety of potatoes was Beauty of Hebron, and the seed stock was purchased in northern Maine. It was prepared for planting by treating with corrosive sublimate on April 10, exposed in a light room in a single layer until April 22, and then cut into pieces of two eyes each. The pieces were planted 1 foot apart in rows 3 feet apart the same day the tubers were cut. The crop was thoroughly cared for throughout the season. It was sprayed with Bowker's prepared insecticide and fungicide four times, June 19 and 28, and July 11 and 26. As in our other experiments, the spraying proved thoroughly effective in destroying bugs, but not entirely so in preventing blight and rot. The growth on both plots was vigorous, and from a very early period there was a marked difference in the shade of green on the two; the vines on the sulfate of potash plot were of a dark-green color, those on the muriate of potash plot were of a light-yellowish — or pea-green color. This difference persisted until the crops began to ripen. On August 5 the tops were generally beginning to show signs of ripeness. On the 12th, blight was general, though not apparently severe. The tops were entirely dead on August 29, on which date the potatoes were dug. They were divided into two grades as to size, the potatoes classed as small including those estimated to be below 2 ounces in weight. There was considerable rot, as a rule of the larger tubers only. The total weight of the decayed potatoes on the muriate of potash plot was 50 pounds, on the sulfate of potash plot 314 pounds. In the estimate of total product these tubers are included with the merchantable. The yields were at the rates per acre shown in the table: —

Muriate v. High-grade Sulfate of Potash. — Potatoes, Yield per Acre (Bushels).

	Muriate of Potash.	High-grade Sulfate of Potash.
Potatoes, merchantable,	208	215
Potatoes, small,	53	39
Totals,	261	254

The total yield on the two plots is nearly the same. The crop on the sulfate of potash averaged of larger size than that on the muriate, but there was most decay on the sulfate. Whether this fact has any special significance it is impossible to say, without repeating the experiment.

4. *Onions (Sulfate v. Muriate of Potash).*

The onions grown in this experiment occupied two plots, 19 and 20. The crop of last year on these plots was cabbages, with winter rye as a cover crop, sown before the cabbages were harvested. The variety of onions was Danvers Yellow Globe. The seed was obtained from Gregory & Son, Marblehead, 1901; it was therefore one year old. It was sown in the thoroughly prepared soil in rows 14 inches apart on April 24. Growth throughout the earlier part of the season was very slow, and the final crop was poor. The fertilizers usually employed on this series of plots were supplemented by the application of a combined form of quick-lime and nitrate of soda, known as "niter-lime,"[1] at the rate of 175 pounds per acre. This was applied on July 12 and cultivated in. Soon after its application growth became much more rapid; but whether this was due chiefly to the somewhat more seasonable weather which then prevailed, or to the application of niterlime, we cannot feel certain. The onions were pulled on September 23, those on the sulfate of potash being more nearly mature than those on the other plot. The yield per acre, in bushels of sound onions and pounds of scallions, is shown in the table: —

Muriate v. High-grade Sulfate of Potash. — Onions, Yield per Acre.

	Muriate of Potash.	High-grade Sulfate of Potash.
Onions (bushels), ...	110	75
Scallions (pounds), ...	10,811	8,828

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[1] Niterlime contains: nitrogen, about 10.5 per cent.; and lime, about 20 per cent.

It will be seen that the muriate of potash has given the larger yield ; but, since the onions on the sulfate were riper than those on the muriate, the figures probably have no special significance.

IV. — FERTILIZERS FOR GARDEN CROPS. (FIELD C.)

The conclusions now presented are based upon the results of experiments which have been in progress since 1891. From that date to 1898 chemical fertilizers alone were used. During the past five years stable manure has been applied in equal quantities (at the rate of 30 tons per acre) to each of the plots, while the chemical fertilizers have been used in the same amounts and applied to the same plots as at first. The crops grown during this series of years have included all important out-door crops: spinach, lettuce, onions, garden peas, table beets, early cabbages, late cabbages, potatoes, tomatoes, squashes, turnips, sweet corn, celery, and one small fruit, — strawberries. Two of the perennial garden crops, asparagus and rhubarb, have now been planted, but these will not be discussed in the present report. Experiments have been planned with reference to throwing light especially upon two points : —

A. The relative value of nitrate of soda, sulfate of ammonia and dried blood as sources of nitrogen.

B. The relative value of sulfate of potash and muriate of potash.

These two points will be separately discussed.

A. — The Relative Value of Nitrate of Soda, Sulfate of Ammonia and Dried Blood as Sources of Nitrogen.

The three fertilizers used as sources of nitrogen have from the first been applied in such amounts as to furnish equal nitrogen to each plot, and each fertilizer is always applied to the same plot. Each of the nitrogen fertilizers is used on two plots, — on one with sulfate of potash, on the other with muriate. Dissolved bone-black as a source of phosphoric acid is applied in equal quantities to all plots. The results previous to this year may be thus summarized : —

For the early crops, *i.e.*, the crops making most of their growth before midsummer, including onions, lettuce, table beets, garden peas, and strawberries, the nitrate of soda has been found the most effective source of nitrogen. The relative standing of the different nitrogen fertilizers is as follows: —

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	92.7
Sulfate of ammonia,	54.8

For late crops, including cabbages, turnips, and celery, the relative standing is: —

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	98.7
Sulphate of ammonia,	77.5

The average rate of yield per plot for each of the nitrogen fertilizers for the present season is shown in the following table: —

Nitrogen Fertilizers compared for Garden Crops. — Yield per Plot (Pounds).

AVERAGE OF TWO PLOTS.	ONIONS.		TOMATOES.		Straw-berries.	Celery.	Squashes.
	Ripe.	Scallions.	Ripe.	Green.			
Nitrate of soda,	367.5	29	235.9	264	125.8	360	841.3
Sulfate of ammonia,	209.5	94	242.1	345	128.4	180	819.6
Dried blood,	357.0	34	403.7	269	146.4	295	807.4

It will be seen that for most of the crops the results are similar to the average results of preceding years. Nitrate of soda, however, stands relatively somewhat lower. Combining the results of this year with those of previous years, the relative standing of the different fertilizers used as sources of nitrogen is as follows: —

For the early crops, including onions and strawberries: —

	Per Cent
Nitrate of soda,	100.0
Dried blood,	93.7
Sulfate of ammonia,	57.3

For the late crops, including tomatoes, celery, and squashes: —

	Per Cent.
Nitrate of soda,	100.0
Dried blood,	99.0
Sulfate of ammonia,	78.4

Since nitrate of soda furnishes a pound of nitrogen at lower cost than any other of the fairly concentrated fertilizers, it becomes very evident, in view of our results, that it should be used as the source of this element as largely as the nature of the conditions permits. It should be remembered, as has been stated in previous reports, that the soil of Field C is a moderately retentive loam. Upon a lighter soil the superiority of the nitrate would probably be less marked. It must again be pointed out that experiments here, as elsewhere, make it very probable that the relative standing of the sulfate of ammonia would be bettered by making a heavy application of lime to the plots where it is used. Since, however, the pound of nitrogen costs more in the sulfate of ammonia than in either the nitrate or the dried blood, it would seem that there can be little probability that the selection of this nitrogen fertilizer is usually wise. Its physical properties, it is true, are such that it is more readily and conveniently used in mixtures with other materials than the nitrate, since the latter attracts moisture, while the sulfate of ammonia does not do this to any considerable extent. If, however, nitrate of soda which has been recently reground and which has been stored in a dry place be used, and if the mixture can be applied soon after it is made, there is little difficulty in employing nitrate.

B. — The Relative Value of Sulfate and Muriate of Potash for Garden Crops.

The history of the plots where these two potash salts are under comparison has been outlined under section *A*. The crops are the same as those which have been named under that section. Each potash salt is used on three plots, *i.e.*, with each of the three nitrogen fertilizers. The results of the past year are shown in the following table: —

Sulfate and Muriate of Potash compared as Fertilizers for Garden Crops. — Yield per Plot (Pounds).

AVERAGE OF THREE PLOTS.	Onions.	Tomatoes.	Strawberries.	Celery.	Squashes.
Muriate of potash,	360	579.8	135.7	270	879.7
High-grade sulfate of potash,	367	593.0	131.4	287	766.2

In the discussion of the relative standing of these two potash salts, the same crops are included respectively under the headings early and late as those specified in section *A*. The relative standing of these two salts at the beginning of the present year is shown in the following table: —

FERTILIZERS.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Sulfate of potash,	100.0	100.0
Muriate of potash,	92.6	103.0

Including the crops of the past year, the relative standing of the two potash salts is as follows: —

FERTILIZERS.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Sulfate of potash,	100.0	100.0
Muriate of potash,	93.2	102.9

Attention is called to the fact that the results of this year are in exact accord with those of earlier years. The sulfate of potash proves considerably superior to the muriate for the crops making most of their growth early in the season, while for those making their growth in the latter part of the season the muriate is slightly superior.

V. — COMPARISON OF DIFFERENT POTASH SALTS FOR FIELD CROPS. (FIELD G.)

Since 1898 the following potash salts have been under comparison for various field crops: kainite, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate, and silicate. Each is applied annually to the same plot, and all are used in such quantities as to furnish equal potash to each plot. All plots are equally manured with materials furnishing nitrogen and phosphoric acid. There are forty plots, in five series of eight plots each, each series including a no-potash plot and one for each potash salt used. The area per plot is about one-fortieth of an acre. The crops on this land last year were winter wheat on one series and ensilage corn on the other four series. On the series occupied by the winter wheat, clover was sown after reploughing, the last of July. On the four series occupied by corn last year clover was sown in the corn early in August. The clover on the series following wheat got an excellent start, and went through the winter well. The clover on the other series, owing to the dense shade of the corn, which was very heavy, made much less growth, and was to a considerable extent winter-killed. On these plots, Nos. 9 to 40, it was necessary to sow additional seed this spring. This was done on March 26, when the soil and weather conditions were favorable. The seed sown at this time started well. The usual fertilizers were applied this spring on April 25. The crop on all the plots was cut on June 11. That on the series which followed wheat was well grown, and the product of each plot was separately weighed. The product of the other plots was much mixed with weeds, which, on account of the winter-killing, were able to make considerable growth; and it was not considered that the weights would have much value, as indicating the relative yield of clover. Before the clover was cut, however, the plots were carefully examined. It was found that on each of the plots to which kainite had been applied the condition of the young clover was much inferior to that of the clover on the other plots. The color was poor, while many of the plants appeared to be dying. This difference was not apparent between the clover plants which had survived the winter on the different plots. Examination disclosed the further fact that there was a somewhat similar degree of inferiority in the condition of the young clover on all of the plots which had received an application either of the low-grade sulfate of potash or of muriate of potash, as compared with that on the other plots.

Indeed, at this time the young clover on all the kainite, low-grade sulfate and muriate of potash plots appeared to be inferior to that on the plots which had received no potash. By the middle of the season there were many places in all these plots on which there was no clover. Before the end of the season, however, such clover plants on these plots as survived became perfectly healthy, and were characterized by a marked degree of vigor. It cannot be doubted, in view of the unfavorable results which have been previously obtained in our experiments where muriate of potash has been used for clover, that it is the chlorides in the three fertilizers which cause the injury. Chlorides may produce this effect either because of the increased loss of lime which their use leads to, or possibly because of the fact that their continued use brings the soil into an acid condition. Either deficiency of lime or presence of free acid is known to be decidedly unfavorable to the growth of clover.

All the plots in the field were cut twice subsequent to June 11, viz., on August 4 and October 10. On the first date there was a moderate growth of small weeds and a few large ones on the plots on which the clover was poor, *i.e.*, on the kainite, muriate of potash, and low-grade sulfate of potash plots. These, as far as practicable, were thrown out. In estimating the significance of the differences in yield, however, it should be remembered that the real difference in the condition and growth of the clover was undoubtedly greater than the figures indicate, as where the clover is weakest the weeds are most numerous, and it is impossible to separate them all. The crops cut were carefully cured in cocks without loss of leaf, and the hay was well dried when weighed. The tables show the rates of yield per acre and the averages for the last two cuttings of the several potash salts: —

Clover. — Yield per Acre (Pounds).

Plots.	POTASH SALT.	Hay.	First Cut, Rowen.	Second Cut, Rowen.	Totals.
1	No potash, ...	2,458	2,078	1,273	5,809
2	Kainite, ...	2,681	2,491	1,475	6,647
3	High-grade sulfate, ...	2,681	2,301	1,564	6,546

Clover. — Yield per Acre (Pounds) — Concluded.

Plots.	POTASH SALT.	Hay.	First Cut, Rowen.	Second Cut, Rowen.	Totals.
4	Low-grade sulfate, ...	2,904	2,324	1,430	6,658
5	Muriate, ...	2,904	2,188	1,609	6,701
6	Nitrate, ...	3,128	2,156	1,475	6,759
7	Carbonate, ...	3,128	2,391	1,430	6,949
8	Silicate, ...	3,128	2,480	1,541	7,149
9	No potash, ...	–	2,100	1,273	3,373
10	Kainite, ...	–	1,966	849	2,815
11	High-grade sulfate, ...	–	2,569	1,296	3,865
12	Low-grade sulfate, ...	–	2,458	1,229	3,687
13	Muriate, ...	–	2,414	1,162	3,576
14	Nitrate, ...	–	2,670	1,162	3,832
15	Carbonate, ...	–	2,458	1,385	3,843
16	Silicate, ...	–	2,793	1,206	3,999
17	No potash, ...	–	2,435	670	3,105
18	Kainite, ...	–	2,145	581	2,726
19	High-grade sulfate, ...	–	2,636	983	3,619
20	Low-grade sulfate, ...	–	2,726	961	3,687
21	Muriate, ...	–	2,547	1,340	3,887
22	Nitrate, ...	–	2,815	1,251	4,066
23	Carbonate, ...	–	2,591	1,117	3,708
24	Silicate, ...	–	2,726	1,251	3,977
25	No potash, ...	–	2,234	626	2,860
26	Kainite, ...	–	2,324	849	3,173
27	High-grade sulfate, ...	–	2,815	1,206	4,021
28	Low-grade sulfate, ...	–	2,525	983	3,508
29	Muriate, ...	–	2,681	938	3,619
30	Nitrate, ...	–	2,748	1,117	3,865
31	Carbonate, ...	–	2,591	1,162	3,753
32	Silicate, ...	–	2,860	1,340	4,200
33	No potash, ...	–	2,435	849	3,284
34	Kainite, ...	–	2,100	760	2,860
35	High-grade sulfate, ...	–	2,703	1,251	3,954
36	Low-grade sulfate, ...	–	2,636	1,162	3,798
37	Muriate, ...	–	2,949	1,072	4,021
38	Nitrate, ...	–	2,681	1,117	3,798
39	Carbonate, ...	–	2,681	983	3,664
40	Silicate, ...	–	2,502	849	3,351

Clover Rowen. — Average Yield per Acre (Pounds).

POTASH SALT.	First Cut, Rowen.	Second Cut, Rowen.
No potash (1, 9, 17, 25, 33),	2,256	938
Kainite (2, 10, 18, 26, 34),	2,205	903
High-grade sulfate (3, 11, 19, 27, 35),	2,605	1,260
Low-grade sulfate (4, 12, 20, 28, 36),	2,534	1,153
Muriate (5, 13, 21, 29, 37),	2,556	1,224
Nitrate (6, 14, 22, 30, 38),	2,614	1 224
Carbonate (7, 15, 23, 31, 39),	2,542	1,215
Silicate (8, 16, 24, 32, 40),	2,672	1,237

The figures call for little comment. They strikingly show the marked inferiority of the product on the plot receiving kainite. Not only is the average product on this plot lower than the yield on any of the other potash salts, — but it is lower in every series except one than the yield on the plot receiving no potash. The potash salt giving the highest average total yield is the silicate, — almost as good is the high-grade sulfate, — while the yield on the nitrate muriate and carbonate is not far behind.

VI. — COMPARISON OF PHOSPHATES ON THE BASIS OF EQUAL APPLICATION OF PHOSPHORIC ACID.

In this experiment, which has been in progress six years, we have under comparison the following phosphates: apatite, South Carolina rock phosphate, Florida soft phosphate, phosphatic slag, Tennessee phosphate, dissolved bone-black, raw bone, dissolved bone, steamed bone, and acid phosphate. The phosphates are all applied in the finely ground form, being carefully spread broadcast after ploughing in the spring, and harrowed in. Three plots in the field have received no phosphoric acid in any form since the beginning of the experiment. The plots are one-eighth of an acre each in area. The phosphates yearly applied are used in quantities sufficient to furnish actual phosphoric acid at the rate of 96 pounds to the acre. All plots are manured alike, with materials furnishing nitrogen and potash in available forms and in equal amounts to each. The materials regularly used furnish nitrogen at the rate of 52 pounds and potash at the rate of 152 pounds per acre. During the past year every plot in the field has received an extra application furnishing nitrogen during the growth of the crop. The material used was niterlime, a combination of nitrate of soda and quicklime, containing 10.44 per cent. nitrogen and 20.41 per cent. lime. This was applied broadcast on July 2, at the rate of 176 pounds per acre, and cultivated in.

The preceding crops have been: corn, cabbages, corn, and in 1900 oats for hay, and Hungarian grass also cut for hay, and onions. With the exception of the onions, all these crops have given large yields, even on the three plots in the field which have received no application of phosphoric acid. Attention is once more called to the fact that the soil of plot 1 seems to have been naturally in a much higher condition of fertility than that of any other plot in the field. In estimating the significance of the results, therefore, the yield of this plot should be disregarded. A more correct indication of the effect of each of the phosphates on plots 2 to 6 is afforded by comparing the yields of those plots with the yield on plot 7. It is, however, without doubt true that the soil from plot 7 towards plot 1 improves gradually in physical condition and natural fertility. The crop the present year has been onions. These throughout this part of the State have generally been a poor crop this year. Our yields are comparatively small even on the best plots. The results are given in the table: —

Onions on Plots with Equal Amounts of Phosphoric Acid.

Plots.	FERTILIZER.	Onions (Bushels per Acre).	Scallions (Pounds per Acre).
1	No phosphate,	195.7	8,560
2	Apatite,	101.7	8,480
3	South Carolina rock phosphate,	121.8	9,360
4	Florida soft phosphate,	52.3	6,880
5	Phosphatic slag,	252.0	5,600
6	Tennessee phosphate,	44.6	6,960
7	No phosphate,	50.5	5,360
8	Dissolved bone-black,	173.8	5,640
9	Raw bone,	301.4	4,144
10	Dissolved bone meal,	388.9	5,400
11	Steamed bone meal,	243.8	5,840
12	Acid phosphate,	159.4	6,560
13	No phosphate,	26.2	6,600

Up to the time when onions were introduced as a crop on this field, the leading conclusions drawn from the experiments were the following: —

1. The phosphatic slag has apparently furnished phosphoric acid in an exceedingly available form, the yield on the plot receiving the slag being almost equal to that on the dissolved bone-black.

2. The Florida soft phosphate has given the lowest yields of any plot receiving phosphoric acid.

3. Steamed bone meal appears to be inferior in availability to raw bone meal.

For last year the phosphates giving the largest yields of sound onions, mentioned in the order of their rank, were: raw bone, phosphatic slag, South Carolina rock phosphate, apatite, dissolved bone meal, and dissolved bone-black. All others gave yields under 200 bushels to the acre.

Examination of the table shows that the results are in general similar to those of last year; the differences, however, are much greater and the apatite and South Carolina rock phosphate take a relatively much lower rank. The dissolved bone meal gives the largest crop; raw bone ranks next; while the phosphatic slag stands next in order, with steamed bone meal not far behind.

The proper ripening of the onion crop, as shown by this as well as other of our experiments, appears to be dependent in very large measure upon the presence of a liberal supply of highly available phosphoric acid. It appears very doubtful, therefore, whether it is likely ever to prove expedient to depend upon natural rock phosphates or untreated bone as a source of phosphoric acid for this crop.

VII. — Soil Tests.

During the past season we have conducted three soil tests, — two upon our own grounds, both in continuation of previous work upon the same fields, and one on the farm of A. M. Lyman of Montague. In these experiments the fertilizers are used in accordance with the co-operative plan for soil tests adopted in Washington in 1889. Each plot receives annually the same kinds of fertilizers, and usually in the same amounts. These experiments are not calculated to secure the production of heavy crops, but are designed rather to throw light upon the general question as to how the different crops should be manured for the most profitable results. The fertilizers are so applied that it becomes possible to determine with much accuracy the effects of each of the leading elements of plant food. Every fertilizer used, whether applied by itself or in connection with one or both of the other fertilizer materials, is always applied in the same quantities. Fertilizers and manures are always applied broadcast after ploughing, and harrowed in. The following table shows the kinds and usual amounts per acre : —

Nitrate of soda, 160 pounds, furnishing nitrogen.
Dissolved bone-black, 320 pounds, furnishing phosphoric acid.
Muriate of potash, 160 pounds, furnishing potash.
Land plaster, 400 pounds.
Lime, 400 pounds.
Manure, 5 cords.

A. — Soil Test with Corn (South Acre), Amherst.

This acre has been used in soil tests for fourteen years, beginning in 1889. The crops in successive years have been as follows: corn, corn, oats, grass and clover, grass and clover, corn (followed by mustard as a catch crop), rye, soy beans, white mustard, corn, corn, grass and clover, grass and clover, and this year corn once more. Since 1889 this field has therefore borne six corn crops, and during this time it has been four years in grass.

It will be noticed that the crop last year was grass. The sod was turned on April 12. The land was thoroughly harrowed, twice before sowing the fertilizer and once after. The variety of corn was Sibley's Pride of the North. It was planted in drills, 3½ feet apart, on May 22. The season was cold and unfavorable to corn, but in spite of this fact the crop made very good growth upon the four plots to which potash has been yearly applied and upon the plot which has been yearly manured. Four of the plots in this field have received no manure nor fertilizer throughout the entire fourteen years, and these show a high degree of exhaustion, — indeed, these produced scarcely any sound grain this year. The crop, however, is not yet sufficiently dried to shell; and calculation, allowing 90 pounds of ears, as weighed November 22, to a bushel, shows that the average apparent yield is at the rate of 9.7 bushels per acre. The actual yield of grain is believed to be under 4 bushels per acre. The table shows the manuring of the several plots, the rate of yield, and the gain or loss per acre compared with the nothing plots: —

Corn. — South Acre Soil Test, 1902.

Plots.	FERTILIZER USED.	YIELD PER ACRE.		GAIN OR LOSS PER ACRE, COMPARED WITH NOTHING PLOTS.	
		Corn (Bushels, 90 Pounds).	Stover (Pounds).	Corn (Bushels, 90 Pounds).	Stover (Pounds).
1	Nitrate of soda,	7.3	1,180	—3.1	—300
2	Dissolved bone-black,	11.4	1,780	1.0	300
3	Nothing,	10.4	1,480	-	-
4	Muriate of potash,	47.7	4,760	37.3	3,507
5	Lime,	4.9	860	—5.5	—167
6	Nothing,	10.4	800	-	-
7	Manure,	68.7	6,220	58.3	5,420
8	Nitrate of soda and dissolved bone-black.	11.2	1,380	2.0	20
9	Nothing,	9.2	1,360	-	-
10	Nitrate of soda and muriate of potash.	53.4	3,540	44.3	2,200
11	Dissolved bone-black and muriate of potash.	55.9	4,640	47.0	3,320
12	Nothing,	8.8	1,300	-	-
13	Plaster,	14.6	1,880	5.8	580
14	Nitrate of soda, dissolved bone-black and muriate of potash.	56.2	4,540	47.4	3,240

The effect of each of the three elements of plant food — nitrogen, phosphoric acid and potash — is more clearly brought out in the tables which follow: —

	RESULTS OF THE ADDITION OF NITROGEN TO —				
	Nothing.	Phosphoric Acid.	Potash.	Phosphoric Acid and Potash.	Average Results.
Corn (bushels),	—3.1	1.0	7.0	.4	1.3
Stover (pounds),	—300	—280	—1,307	—80	—492

Value of decrease,	$0 45
Financial result (loss),	3 65

	Results of the Addition of Phosphoric Acid to—				
	Nothing.	Nitrogen.	Potash.	Nitrogen and Potash.	Average Results.
Corn (bushels), . .	1.0	5.1	9.7	3.1	4.7
Stover (pounds), . .	300	320	—187	1,040	368

Value of increase, ...	$3 74
Financial result (gain), ...	54

	Results of the Addition of Potash to—				
	Nothing.	Nitrogen.	Phosphoric Acid.	Nitrogen and Phosphoric Acid.	Average Results.
Corn (bushels), . .	37.3	47.4	46.0	45.4	44.0
Stover (pounds), . .	3,507	2,500	3,020	3,220	3,062

Value of increase, ...	$34 06
Financial result (gain), ...	30 86

	Results of the Addition to Nothing of—			
	Lime.	Manure.	Plaster.	Complete Fertilizer.
Corn (bushels), ...	—5.5	58.3	5.8	47.4
Stover (pounds), ...	—167	5,420	580	3,240
Value of increment, ...	-	$48 53	$4 93	$36 54
Value decrease, ...	$3 72	-	-	-
Financial result, ...	$6 12 loss.	$23 53 gain.	$1 33 gain.	$26 94 gain.

The Effect of the Nitrogen. — It will be noticed that the employment of nitrate of soda alone (nitrogen) gives a crop which is actually less than that produced where no fertilizers are used. This variation is very likely accidental, as it can hardly be supposed that the nitrate is actually injurious. When used with potash alone, the nitrate gives a moderate increase in the crop. The average result is an increase of a little more than a bushel of grain, but a decrease of nearly 500 pounds in stover. The nitrate does not pay for itself, on either of the four plots to which it was applied; for the cost of the 160 pounds is $3.60, and on the only plot where the increase in grain is sufficient to be worth this sum there is a decrease in the amount of stover, which brings the net increased value below the cost of the nitrate.

The Effect of the Phosphoric Acid. — Dissolved bone-black (phosphoric acid) used alone produced an insignificant increase. In the different combinations the results of its use indicate it to be moderately beneficial. The best result is secured where it is employed in connection with potash. The cost of the dissolved bone-black wherever employed was at the rate of about $3.20 per acre. The average increase in crop is sufficient to barely cover this amount. Particular attention is called to the splendid crop produced where dissolved bone-black and muriate of potash are used together. The combination of these two fertilizers without nitrogen apparently suffices, under the system of rotation which has been followed, to fully maintain the productiveness of this plot. Last year its yield was at the rate of 1,900 pounds of hay to the acre in the first crop and 1,500 pounds of rowen in the second crop. As was pointed out last year, this splendid product is undoubtedly due to the capacity which clover grown in mixture with the grasses possesses to draw the needed nitrogen from the air. The advantage obtained by this system of manuring is, however, not exhausted when we have taken the hay crops; for, as shown by the yield of corn this year of almost 56 bushels of sound grain to the acre, the corn crop which requires a large amount of nitrogen (which, so far as we know, must be taken from the soil), is able to derive the needed quantity of this element from the products of the decay of the clover roots and stubble. The expenditure for fertilizers applied to this plot has been at the rate of about $6.40 per acre, and for this sum we have this year nearly 56 bushels of corn and more than 2½ tons of stover. Moreover, the beneficial effects of this system of manuring appear to be cumulative. The productivity of this plot shows not the slightest signs of decrease after fourteen years, during which time neither manure nor fertilizer furnishing a single ounce of nitrogen has been applied. In view of the results upon other plots, it cannot be doubted that the increased yield on this plot is due in very large measure to the potash employed, but the dissolved bone-black is also evidently useful.

The Effect of the Potash. — It will be noticed that wherever potash is applied, whether alone or in combination with either one or both of the other fertilizers, the result is a large yield. Potash is evidently the dominant plant food element on this soil for corn. The increase where this element is used alone is at the rate of more than 37 bushels to the acre; the average increase, at the rate of 44 bushels to the acre. The potash used costs at the rate of $3.20 per acre. This amount is covered many times over by the increase in the crop.

The Effect of the Manure. — The manure alone gives a large crop, — considerably larger than on any other plot. That this should be true is natural, in view of the fact that the manure at the rate at which it is applied furnishes a larger amount of plant food than is furnished in the fertilizers. It also tends to keep up the supply of humus in the soil, and this, as is well understood, is highly beneficial in many ways. The yearly cost of the manure applied is, however, at the rate of about $25 per acre, while the complete fertilizer used on plot 14 costs only $10.

The results with corn this year are entirely similar in kind to those which have been obtained in the earlier years in which corn has been grown on this piece of land. They show very conclusively that on such land corn can be cheaply grown by the use of fertilizers alone, and they demonstrate conclusively that potash should be a very prominent constituent. In view of the fact that the fertilizers generally used by the farmers of the State for corn usually contain far more phosphoric acid than potash, these results appear to be well worth attention. The important question naturally at once arises, "How far are the requirements of the corn crop on the farms in other parts of the State similar to those shown by these experiments?" In answer to this question, attention is called to the results of similar experiments in various parts of the State, which have been published in Bulletins Nos. 9 and 14 of this station. These results indicate that in most localities the potash in fertilizers appears to have a greater effect in increasing the corn crop than either of the other prominent elements. Especially has this been found to be the case on the better soils of the State. The results upon light and poor soils in Yarmouth, Freetown and Marblehead have shown but small increase for any of the fertilizers used. On such soils farmyard manures prove much the most effective. On the soils with good physical characteristics, *i.e.*, soils on which crops are not likely to suffer excessively in hot, dry weather, and especially if the soil is one which is in a fair state of fertility, the increase due to potash has always been found to be striking, and it is believed that farmers should see to it that this element is more largely supplied to this crop.

B. — Soil Test with Potatoes (North Acre).

The field on which this test was carried out has been used in similar tests with various crops for thirteen years, beginning in 1890. The crops grown in order of succession include potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and rutabaga turnips, potatoes, and onions, for four years (1898 to 1901 inclusive).

Rye was sown a short time before the onion crop of last year was pulled, in the hope of producing a crop which would serve as winter cover, and to prevent washing, to which this field is liable. This object was only in part accomplished, as the rye sown on the surface did not make a perfect start. There was considerable washing, as a result of heavy storms in March. It is not believed, however, that this was of such a character as seriously to interfere with the accuracy of our fertilizer tests, for it was for the most part with and not across plots. The several plots in this field have been manured in accordance with the usual soil test plan, with the exception that double quantities of all fertilizer materials were used during the years when onions have been grown, as well as this year. In one other respect the treatment of this field has been peculiar. The lower half of all plots received an application of lime in the spring of 1898 at the rate of 1 ton to the acre. The nitrate used during the present season was put on in two applications, — one-half applied broadcast just before planting the seed, the other half scattered about the plants and cultivated in on June 30, at which time the crop was about half grown. The field was ploughed on May 7, at which time the rye had made considerable growth. There were marked differences on the different plots, but no clearly defined difference beween the limed and unlimed portions of the several plots. The fertilizers in double the usual amounts were spread broadcast on May 12 and immediately harrowed in. The variety of potatoes planted was the Delaware, the seed being grown in the adjoining town of Hadley. In preparation for planting the seed was soaked in a solution of corrosive sublimate, for the prevention of scab. It was then dried, and the tubers were cut into pieces with two good eyes each, and planted at once. The date of planting was May 13. The potatoes started well, the crop was thoroughly cared for, and there were no accidental conditions recognized as interfering with the normal development of any of the plots. The potatoes were sprayed twice, — on July 11 with Bowker's Boxal, and on July 26 with Bowker's Bodo, to which a suitable quantity of Paris green for destruction of bugs was added. Both sprayings were effective in destroying bugs but not fully effective in preventing blight, which, however, was not serious on this field, where the growth of the tops was comparatively light. There was no rot whatever, although this disease was prevalent on similar soils in the immediate neighborhood. The crop was dug on September 8 and 9. All tubers were smooth, but of rather small average size; they were, however, of excellent quality. The following tables show the fertilizers applied to the several plots, the yields per acre, and the gain or loss compared with the nothing plots: —

Potatoes. — North Acre Soil Test (Unlimed), 1902.

Plots.	FERTILIZERS USED.	YIELD PER ACRE (BUSHELS).		GAIN OR LOSS PER ACRE COMPARED WITH NOTHING PLOTS (BUSHELS).	
		Merchantable.	Small.	Merchantable.	Small.
1	Nothing, ...	27.7	24.0	-	-
2	Nitrate of soda, ...	30.0	20.7	1.1	—2.9
3	Dissolved bone-black, . .	39.3	20.0	9.2	—3.1
4	Nothing, ...	31.3	22.7	-	-
5	Muriate of potash, . . .	58.0	15.3	25.7	—9.1
6	Nitrate of soda and dissolved bone-black.	69.3	28.7	36.0	2.7
7	Nitrate of soda and muriate of potash.	51.3	26.0	17.0	—1.7
8	Nothing, ...	35.3	29.3	-	-
9	Dissolved bone-black and muriate of potash.	73.7	18.0	41.1	—9.4
10	Nitrate of soda, dissolved bone-black and muriate of potash.	110.3	17.0	80.4	—8.5
11	Plaster, ...	24.7	16.0	—2.5	—7.6
12	Nothing, ...	24.5	21.7	-	-

Potatoes. — North Acre Soil Test (Limed), 1902.

Plots.	FERTILIZERS USED.	YIELD PER ACRE (BUSHELS).		GAIN OR LOSS PER ACRE COMPARED WITH NOTHING PLOTS (BUSHELS).	
		Merchantable.	Small.	Merchantable.	Small.
1	Nothing, ...	21.3	27.7	-	-
2	Nitrate of soda, ...	27.3	20.3	5.5	—5.3
3	Dissolved bone-black, . .	26.0	22.0	2.2	—1.4
4	Nothing, ...	22.7	21.3	-	-
5	Muriate of potash, . . .	69.0	12.7	43.8	—8.6
6	Nitrate of soda and dissolved bone-black.	71.3	29.0	43.6	7.7
7	Nitrate of soda and muriate of potash.	58.3	17.3	28.1	—4.0
8	Nothing, ...	32.7	21.3	-	-
9	Dissolved bone-black and muriate of potash.	93.7	20.0	61.6	—.3
10	Nitrate of soda, dissolved bone-black and muriate of potash.	115.3	17.3	83.8	2.0
11	Plaster, ...	24.3	13.7	—6.6	—4.6
12	Nothing, ...	30.3	17.3	-	-

POTATOES (BUSHELS PER ACRE).	RESULTS OF THE ADDITION OF NITROGEN TO—				
	Nothing.	Phosphoric Acid.	Potash.	Phosphoric Acid and Potash.	Average Results.
Unlimed:—					
Merchantable, . .	1.1	26.8	—8.7	39.3	14.6
Small,.	—2.9	5.8	7.4	.9	2.8
Limed:—					
Merchantable, . .	5.5	39.8	—15.7	22.2	13.0
Small,.	—5.3	9.1	4.6	2.3	2.7

Value of increase, unlimed, ...	$9 32
Financial result, unlimed (gain), ...	2 92
Value of increase, limed, ...	8 34
Financial result, limed (gain), ...	1 94

POTATOES (BUSHELS PER ACRE).	RESULTS OF THE ADDITION OF PHOSPHORIC ACID TO—				
	Nothing.	Nitrogen.	Potash.	Nitrogen and Potash.	Average Results.
Unlimed:—					
Merchantable, . .	9.2	34.9	15.4	63.4	30.7
Small,.	—3.1	5.6	—.3	—6.8	—1.2
Limed:—					
Merchantable, . .	3.8	38.1	17.8	55.7	28.9
Small,.	—1.4	13.0	8.3	6.0	6.5

Value of increase, unlimed, ...	$18 18
Financial result, unlimed (gain), ...	11 78
Value of increase, limed, ...	18 64
Financial result, limed (gain), ...	12 24

POTATOES (BUSHELS PER ACRE).	RESULTS OF THE ADDITION OF POTASH TO—				
	Nothing.	Nitrogen.	Phosphoric Acid.	Nitrogen and Phosphoric Acid.	Average Results.
Unlimed:—					
Merchantable, . .	25.7	15.9	31.9	44.4	29.5
Small,.	—9.1	1.2	—6.3	—11.2	—6.4
Limed:—					
Merchantable, . .	43.8	22.6	57.8	40.2	41.1
Small,.	—8.6	1.3	1.1	—5.7	—3.0

Value of increase, unlimed, ...	$16 42
Financial result, unlimed (gain), ...	10 02
Value of increase, limed, ...	24 06
Financial result, limed (gain), ...	17 66

Potatoes (Bushels per Acre).	Results of the Addition to Nothing of —	
	Complete Fertilizer.	Plaster.
Unlimed: —		
Merchantable,	80.4	—2.5
Small,	—8.5	—7.6
Limed: —		
Merchantable,	83.8	—6.6
Small,	2.0	—4.6
Value of increase, unlimed,	$46.64	-
Value of decrease, unlimed,	-	$3.02
Financial result, unlimed,	27.44 gain	6.62 loss
Value of increase, limed,	50.68	-
Value of decrease, limed,	-	4.88
Financial result, limed,	31.48 gain	8.48 loss

It will be noticed that no plot in the field has produced what is regarded as a good crop. This field has now been tilled for several years without the introduction of a grass crop, and the stock of humus in the soil must be exceedingly small. It is believed that this deficiency in humus, on the presence of which, in moderate quantity, potatoes are known to be quite dependent, accounts in a measure for the relatively low yield on the plot to which a complete fertilizer was applied. It will be noticed, further, that there is not a very wide difference between the yields of the unlimed and limed portions of the several plots. With onions as a crop the difference is very large on all plots to which muriate of potash, nitrate of soda, or both of these fertilizers without dissolved bone-black are applied. The fact that potatoes show a far smaller difference may be due to either of two causes: first, that this crop is less sensitive to a deficiency of lime than onions; or, second, that the effects of the lime applied in 1898 are now largely exhausted. We have some evidence that this effect is so exhausted. The soil on the limed portion of the plots manured with muriate of potash or nitrate of soda, as shown by chemical tests, appears to be once more acid.

The Effect of the Nitrogen. — It will be remembered that nitrate of soda was applied to the four plots receiving this fertilizer in double the usual quantities, viz., at the rate of 320 pounds per acre. It increases the crop to a considerable extent only where it is used in connection with dissolved bone-black. Used in connection with this fertilizer, it gives an increase sufficient, with potatoes at 60 cents per bushel, to much more than cover the cost. The fact that it does not give an increase when used in connection with potash (which as will be seen later was the most useful of the fertilizer elements) is strongly indicative of the fact that the soil on the plot receiving nitrate and muriate of potash is once more acid, even on the part limed in 1898. A study of the results leads to the conviction that the experiment furnishes but an imperfect test as regards the necessity of an application of nitrogen on account of the poor physical and chemical condition of the soil, due to deficiency both of humus and lime.

The Effect of the Phosphoric Acid. — The dissolved bone-black (furnishing phosphoric acid), when used in connection with either or with both of the other fertilizers, gives an increase more than sufficient to cover its cost. It gives the largest increase in connection with both of the other fertilizers, which indicates a high degree of general exhaustion. It gives the smallest increase when used in connection with muriate of potash, which is still further evidence of the probable deficiency of lime, for such deficiency is known to be most marked where muriate of potash is largely employed as a fertilizer.

The Effect of the Potash. — The increase in crop produced by the application of muriate of potash where it is used alone or with either or both of the other fertilizers is in all cases much more than sufficient to cover the cost of the fertilizer. The increase on the limed half of the plots is without exception, if small and large tubers both be included, considerably greater than on the unlimed portion of the plots; indicating that, although there may be a present deficiency in the amount of lime necessary for the best results, the effects are not yet wholly exhausted. In practically all soil tests which have been carried out by this station, whether on this farm or on farms in other parts of the State, the potato crop has always shown a marked dependence upon a liberal supply of potash, which we may safely say, therefore, should be more prominent than it usually is in the special fertilizers made for this crop. It seems worth while to call attention here to the fact that, for the sake of uniformity in soil test-work, the potash salt here employed was the muriate. It will be remembered that it has been shown as a result of numerous experiments here that the sulfate is preferable, giving better results, as indicated both by yield and quality.

VIII. — Manure Alone *v.* Manure and Potash.

This experiment was begun in 1890, and is intended to illustrate the relative value in crop production of an average application of manure, as compared with a smaller application of manure in connection with a potash salt. Full accounts will be found in the preceding annual reports, and summaries in the reports for 1895 and 1900. The field is level, and the soil of apparently even quality. It is divided into four quarter-acre plots. The crop for the years 1890 to 1896 was corn; for the years 1897 and 1898, mixed grass and clover; for the years 1899 and 1900, corn; for the past two years, mixed grass and clover. The present is therefore the second year that the land has been continuously in grass. Plots 1 and 3 received an application of manure at the rate of 6 cords per acre; plots 2 and 4, manure at the rate of 4 cords per acre, and high-grade sulfate of potash at the rate of 160 pounds per acre. The annual cost of the manure as applied to plots 1 and 3 is estimated to be at the rate of $30 per acre. The annual cost of the manure and the potash salt applied to plots 2 and 4 at the same price per cord for the manure is at the rate of $23.60 per acre. The yields for the present season are shown in the table: —

Yields of Hay and Rowen (Pounds).

PLOTS.	Hay.	Rowen.
Plot 1,	955	740
Plot 2,	915	690
Plot 3,	1,010	780
Plot 4,	900	680

The rates of yield per acre are shown below: —

Yield of Hay and Rowen per Acre (Pounds).

PLOTS.	Hay.	Rowen.	Total.
Plot 1,	3,820	2,860	6,680
Plot 2,	3,660	2,760	6,420
Plot 3,	4,040	3,120	7,160
Plot 4,	3,600	2,720	6,320

Averaging the yields for plots 1 and 3, we find the total to be at the rate of 6,920 pounds per acre. A similar average for plots 2 and 4 gives a yield at the rate of 6,370 pounds per acre. The larger application of manure therefore gives a yield at the rate of 450 pounds per acre more than the smaller application of manure and the potash. The difference in cost of the two applications, as shown above, is at the rate of $6.40 per acre. The 450 pounds of hay costs, therefore, this amount standing in the field. Grass standing in the field cannot be considered to be worth in an average season more than about $7 or $8 per ton of well-made hay. Although, therefore, we have a small difference in favor of the larger application of manure in total crop, the financial outcome is clearly in favor of the combination of the lesser amount of manure and the potash salt.

We have now grown on this field under substantially the present system of manuring nine corn crops and four hay crops, and the results may be briefly stated as follows: —

1. The corn crops under the two systems of manuring have been practically equal in value.

2. The hay crops have been slightly larger on the plots receiving the more liberal application of manure alone; but these increases have been produced at a cost, where manure is estimated at $5 per cord in the field, which is greater than their value.

IX. — SPECIAL CORN FERTILIZER *v.* FERTILIZER RICHER IN POTASH.

This field has been used continuously in experiments designed to throw light upon the question of the proper use of fertilizers for the corn crop since 1891. From that year to 1896 inclusive the crop was corn; in 1897 and 1898 the crop was mixed grass and clover; in 1899 and 1900, it was corn; and for the past two years, it has been grass and clover. A full account of results to date will be found in preceding annual reports. The especial object in view is to test the question as to whether the special corn fertilizers offered in our markets are of such composition as is best suited for the production of corn in rotation with mixed mowing. The field is divided into four quarter-acre plots, and throughout the entire period during which the experiment has continued two of these plots (1 and 3) have yearly received an application of mixed fertilizers, furnishing the same amounts of nitrogen, phosphoric acid and potash as would be furnished by 1,800 pounds of fertilizer of the composition of the average of the special corn fertilizers analyzed at this station. This average in 1899, since which date there has been no change in the kinds and amounts of fertilizers used, was as follows: —

	Per Cent.
Nitrogen,	2.37
Phosphoric acid,	10.00
Potash,	4.30

The fertilizers analyzed varied widely in composition, the range for each of the elements being shown by the following: —

	Per Cent.
Nitrogen,	1.5– 3.7
Phosphoric acid,	9.0–13.0
Potash,	1.5– 9.5

The other two plots (2 and 4) have annually received an application of materials substantially the same in kind and quantity as those recommended in Bulletin No. 58 for corn on soils poor in organic matter. The essential difference between the applications on the two pairs of plots is that 2 and 4 receive materials furnishing a much larger quantity of potash and much less phosphoric acid than the other pair of plots. The fertilizers applied to the several plots are shown below: —

FERTILIZERS USED.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4 (Pounds Each).
Nitrate of soda,	30.0	50.0
Dried blood,	30.0	–
Dry ground fish,	37.5	50.0
Acid phosphate,	273.0	50.0
Sulfate of potash,	37.5	62.5

The present is the second season that this field has now been in grass. The past season has been favorable to the hay crop, the field was cut twice, and the hay was weighed and housed in excellent condition. The tables show the yields: —

Yields of Hay and Rowen, 1902 (Pounds).

PLOTS.	Hay.	Rowen.	Total.
Plot 1 (lesser potash),	3,712	1,540	5,252
Plot 2 (richer in potash),	5,072	1,900	6,972
Plot 3 (lesser potash),	3,992	1,260	5,252
Plot 4 (richer in potash),	5,012	1,560	6,572

Averaging the two pairs of plots, we have the rates of yield per acre for hay, rowen and total shown below: —

Average Yield per Acre (Pounds).

PLOTS.	Hay.	Rowen.	Total.
Plots 1 and 3,	3,852	1,400	5,252
Plots 2 and 4,	5,042	1,730	6,772

It will be noticed that the yields both of hay and rowen were considerably heavier on plots 2 and 4 (*i.e.*, the plots which received fertilizers richer in potash) than on the other pair of plots. The proportion of clover was much the larger on plots 2 and 4; and, as clover is superior in nutritive value to grass, it is evident that the superiority of the crop was even greater than the weight difference in yield in itself indicates. The cost of the fertilizers applied to plots 1 and 3 exceeds that of the fertilizers applied to plots 2 and 4 at the rate of about $4 per acre. We have, then, as a result of this experiment for this year, 6,772 pounds of hay of superior nutritive value, produced at a cost of $4 less than the 5,252 pounds produced by the other pair of plots. This result is in exact accordance with the teachings of the soil test on the south acre. There can be no doubt that potash should be more abundant in fertilizers for corn than is usually the case. It is important to point out the further fact that the difference between the two pairs of plots, as indicated by the greater productivity of the plots receiving the heavier application of potash, seems to be increasing from year to year. The results of this experiment to date may be briefly stated as follows: —

1. The crops of corn thus far have been substantially equal under the two systems of manuring.

2. The crops of hay have always been larger on the plots where more potash has been used, and the nutritive value pound for pound has been greater on account of the larger proportion of clover.

In conclusion, I may quote from my report for last year: —

> In view of the fact that the clover sod when turned is exceedingly favorable for succeeding crops, it is confidently anticipated

that the differences in yields under the two systems of manuring will increase from year to year, and that the superiority of the mixture of fertilizers containing more potash will therefore become increasingly evident.

X. — Experiment in manuring Grass Lands.

In this experiment, which has continued since 1893 upon one uniform system, our object is to test the value for production of grass of the system of using wood ashes, ground bone and muriate of potash, and manure, in rotation. Owing, however, to the fact that the land has been for many years in grass, and that it has never been cultivated consecutively for a sufficiently great length of time to free it from weeds, the sod had become considerably infested with daisies, ragged robin, buttercups, and a number of other species. It has accordingly been decided to break up and reseed a part of the land. A portion has been cultivated for two years, and is now reseeded. This portion constitutes a part of plot 3. This year, after the harvest of the first crop, which was cut early to avoid ripe weed seeds, a portion each of plots 1 and 2 was broken up. This was frequently harrowed between the date of ploughing, which was about the middle of July, and the date of seeding, which was August 15. The portion of plot 3 not previously broken up has been similarly treated. The area reported upon this year, therefore, comprises only a portion of the plots included in this field, the total area of which is about nine acres.

The rates at which the several manures are employed are as follows: wood ashes, 1 ton per acre; ground bone, 600 pounds, and muriate of potash, 200 pounds, per acre; manure, 8 tons per acre.

The plot which receives wood ashes one year is the next year manured with bone and potash, and the third year with manure.

The manuring of the several plots is so planned that each year we have one plot under each of the systems of manuring. For the last three years the plots receiving respectively wood ashes and bone and potash have also received nitrate of soda at the rate of 150 pounds per acre. The manure is always applied in the fall; the ashes, and the bone and potash and the nitrate of soda, in early spring.

The past season has been in general favorable to the hay crop, but our yields on this field are lower than usual, chiefly, it is believed, on account of the fact that both the first and second cuttings were made earlier than usual, which, as has been stated, was for the purpose of avoiding ripe weed seeds. The yields of hay, and of rowen, where any was cut, and the totals for each system of manuring, were as follows: —

FERTILIZERS USED.	Hay (Pounds).	Rowen (Pounds).	Total (Pounds).
On barnyard manure,	2,396	1,805	4,201
On bone and potash and nitrate of soda,	2,661	1,242	3,903
On wood ashes and nitrate of soda,	3,723	–	3,723

The average yield of the entire area for this year is 3,942 pounds; the average for the period 1893 to the beginning of the present year was 6,619 pounds; the average to date, 6,413 pounds. The plots when dressed with manure have averaged 6,655 pounds; when dressed with bone and potash, 6,420 pounds; and when dressed with wood ashes, 6,094 pounds. The average yields for this year, as will be seen, are materially below the general averages. As has been stated, this is undoubtedly accounted for chiefly by the difference in the time of cutting. The average even for this year constitutes a very satisfactory crop, and for the entire period is such as to render the hay crop, at the prices which the manures used cost, a decidedly profitable one.

XI. — EXPERIMENT IN THE APPLICATION OF MANURE.

The experiment now to be reported is in continuation of work begun in 1899. It has for its object to determine whether it is better to spread fresh manure during late fall and winter, allowing it to remain upon the surface until spring, or to put the manure when hauled out into large heaps, to be spread just before ploughing the land in the spring. A full account of the plan of the experiment will be found in the last annual report. The field contains five plots, one-half of each having the manure spread in winter, the other half put into a large heap and spread in spring. We have, in reality, then, five parallel experiments yearly. In 1901 this field produced a crop of Japanese barnyard millet. After the millet was harvested, the field was ploughed and sown to winter rye, which served as a cover crop. During the past season the field has been in corn for the silo. The soil is naturally cold, and with the cool summer it produced but a small yield. The actual and relative yields of the several plots of rather more than one-fourth acre each are shown in the following table : —

Actual and Relative Yields of Ensilage Corn.

Plots.	MANURING PREVIOUS TO 1899.	ACTUAL YIELDS (POUNDS).		RELATIVE YIELDS (PER CENT.).	
		North Half, Winter Application.	South Half, Spring Application.	North Half, Winter Application.	South Half, Spring Application.
1	Barnyard manure,	5,275	5,480	100	103.9
2	Wood ashes,	4,780	4,650	100	97.3
3	No manure,	2,600	3,900	100	150.0
4	Fine-ground bone and muriate of potash.	4,480	4,105	100	91.6
5	Fine-ground bone and sulfate of potash.	4,905	5,325	100	108.6

In previous years the south half (spring manured) of each plot has without exception given a much superior yield to the north half. This year there are two exceptions: plot 2, where the difference, however, is very small; and plot 4, where there is a difference of 375 pounds in favor of the north or winter-manured half. It must be stated, however, that, owing to unavoidable conditions, one load of the corn on the south half of plot 4 lay upon the ground as it was cut from Saturday night until Monday. There can be no doubt that there was a considerable loss of weight, due to drying. We must not, therefore, attach any special significance to the results upon this plot. The results upon the others are practically confirmatory of the results of previous years. The differences, however, are considerably less. In 1900, the yield of the winter-manured portion of each plot being considered as 100, the yields of the spring-manured portion of the plots varied from 103 to 125. In 1901 the relative yields of the spring-manured plots, on the same basis, varied from 118 to 177. The smaller differences this year are believed to be in part at least a consequence of the fact that the conditions prevailing during the winter of 1901 and 1902 were such that there was much less washing over the surface of the plots, which, it will be remembered, slope lengthwise, than during the two preceding winters. The smaller differences may also be in part due to the unfavorable effects of the season, which prevented entirely normal development on any part of the field. It is believed that our experiments indicate decisively the necessity of greater care than is always taken to avoid spreading manures on slopes during late fall and winter. Our differences in yield this year are not, it is true, sufficiently great to pay for the extra cost of rehandling the manure, which is first piled in the field. During the two past years the differences in crops have been much more than sufficient to pay this extra cost. The experiment will be continued.

XII. — NITRATE OF SODA FOR ROWEN.

The present is the third year during which we have conducted experiments for the purpose of determining whether an application of nitrate of soda after the harvest of the first crop of hay will give a profitable increase in the rowen crop. The results for the two preceding years have with one exception on a timothy sod shown an increase more than sufficient to cover the cost of the nitrate and its application. The experiments of this year were carried out upon a timothy sod which was seeded in 1899. This mowing was top-dressed this spring as follows: —

	Pounds per Acre.
Nitrate of soda,	150
Fine-ground bone,	400
Muriate of potash,	200

The product at the first cutting was at the rate of 5,640 pounds of hay per acre.

Eight equal plots were laid out, and on the alternate plots nitrate of soda was applied, — to two at the rate of 150 pounds to the acre, to one at the rate of 200 pounds, and to another at the rate of 250 pounds. The first crop of timothy was cut on July 11 and 14. The nitrate was applied on July 22. The rowen was cut on September 22 and weighed on October 3, in good condition. The rates of yield per acre are shown in the following table: —

Plots.	FERTILIZERS USED.	Pounds.
Plot 1, ...	No nitrate, ...	459
Plot 2, ...	Nitrate of soda, 150 pounds, ...	826
Plot 3, ...	No nitrate, ...	367
Plot 4, ...	Nitrate of soda, 150 pounds, ...	789
Plot 5, ...	No nitrate, ...	257
Plot 6, ...	Nitrate of soda, 200 pounds, ...	1,320
Plot 7, ...	No nitrate, ...	587
Plot 8, ...	Nitrate of soda, 250 pounds, ...	1,542

The average results were as follows: —

	Pounds.
Average no-nitrate plots, ...	417.5
Average increase due to application of 150 pounds of nitrate,	390.0
Increase due to application of 200 pounds of nitrate, . .	902.5
Increase due to application of 250 pounds of nitrate, . .	1,124.5

The moisture conditions on the different plots of this field, which is of considerable length, are not exactly uniform, being somewhat more favorable toward that end of the field on which the larger applications of nitrate of soda were made. It is believed that this difference in moisture conditions in part accounts for the better apparent effect of the nitrate where applied in the larger quantities. If we determine the increases apparently due to the nitrate by comparison of the yields on plots to which such application was made with the nearest nothing plots only, the apparent effect is as follows: —

	Pounds.
Average increase due to application of 150 pounds of nitrate,	446.5
Increase due to application of 200 pounds of nitrate, . .	898.0
Increase due to application of 250 pounds of nitrate, . .	955.0

All these increases are more than sufficient to cover the cost of the application of nitrate made.

XIII. — Variety Test, Potatoes.

During the past year we have grown, under conditions allowing a fair opportunity for comparison, thirty-three varieties of potatoes. The seed of all varieties was the first generation of our own growing. We included for purposes of comparison an equal area of one of the standard varieties, — Beauty of Hebron, — with seed of the second generation, from northern Maine. We raise our own seed, because it is recognized that the locality in which seed stock is produced and the way in which it is stored and handled has much to do with its productive capacity. We cultivate all varieties of potatoes that we test, therefore, two years, the first year being the preliminary test, made with small quantities of seed gathered from the many different sources from which a list of varieties must be made up. It is the product of this first crop that we use a second year in a final test, the seed of all varieties being stored and handled in precisely the same way. It is the results of this second year's test which are here reported.

The seed tubers planted this year were selected to as nearly as possible an average size of 60 grams in weight for each variety. The tubers were treated with corrosive sublimate in the ordinary way on April 9, and were spread in a light and sunny room in a single layer until May 14, when they were planted, being first cut to pieces of two good eyes each. The pieces were planted 1 foot apart in rows 3 feet apart. The field is one which has been used for a number of years in experiments with corn, in growing which a moderate application of fertilizers alone has been made.

The soil is a medium loam underlaid by gravel, and with perfect natural drainage, — a good potato soil. It received this year an application of manure from milch cows at the rate of 4 cords per acre. A fertilizer mixture was made, containing: —

	Pounds.
Nitrate of soda, ...	80
Dried blood, ...	100
Dry ground fish, ...	180
Acid phosphate, ...	280
High-grade sulfate of potash, ...	160

This mixture was used in the drill, being scattered widely the full length of the open furrow at the rate of 1,600 pounds per acre. The crop was thoroughly cared for, and sprayed three times with a combined insecticide and fungicide. This application did not prove altogether effective, although there was no rot. Growth was normal, and no signs of blight appeared until early in August. The varieties on which it showed itself previous to August 10 were: All the Year Round, Daughter of Early Rose, Early Carmen, Early Trumbull, Early Eureka, Early Rose, Early Pioneer, Ensign Bagley, Ford 1902, Harvest King, Honoeye Rose Seedling, Northern Beauty, New England Thoroughbred, Sunlight, and Smith's Six Weeks. Those on which it showed itself later than August 20, and which therefore may fairly be considered unusually disease-resistant, were: Livingston, Million Dollar, Mark Hanna, and Smith's '99.

The table shows the dates at which the vines of the several varieties were completely dead, and the rates of yield per acre for each: —

VARIETY.	Vines Dead.	Merchantable (Bushels).	Small (Bushels).
All the Rear Round, ...	Aug. 5, .	165.9	41.5
Arcadia, ...	Aug. 30, .	235.4	12.5
Beauty of Hebron (first generation from Maine seed).	Aug. 30, .	315.3	16.6
Beauty of Hebron (second generation from Maine seed).	Aug. 30, .	298.7	24.9
Daughter of Early Rose, ...	Aug. 30, .	256.2	35.3
Early Carmen, ...	Aug. 16, .	170.0	23.9

VARIETY.	Vines Dead.	Merchantable (Bushels).	Small (Bushels).
Early Trumbull,	Aug. 20,	242.7	28.0
Early Eureka,	Aug. 20,	232.3	27.0
Early Rose,	Aug. 25,	258.2	36.3
Early Pioneer,	Aug. 20,	185.7	27.0
Early Nancy,	Aug. 30,	273.8	35.3
Ensign Bagley,	Aug. 25,	262.4	50.8
Ford 1902,	Aug. 25,	73.5	13.0
Gem of Aroostook,	–	258.2	51.8
Harvest King,	Aug. 30,	248.9	20.8
Hammond's Wonderful,	Aug. 5,	224.0	22.8
Honoeye Rose Seedling,	Aug. 25,	177.4	31.1
I. X. L.,	Aug. 30,	298.7	53.9
Livingston,	Aug. 30,	161.8	37.3
Million Dollar,	Aug. 30,	265.5	9.3
Mark Hanna,	Aug. 30,	210.5	10.4
Northern Beauty,	Aug. 30,	245.8	47.7
New England Thoroughbred,	Aug. 30,	232.3	60.2
Rough Rider,	Aug. 30,	214.5	43.6
Rose of the North,	Aug. 30,	239.5	41.5
Stevens,	Aug. 25,	148.3	38.4
Steuben,	Aug. 30,	297.7	35.3
Sunlight,	Aug. 25,	224.0	49.8
Smith's Six Weeks,	Aug. 30,	65.3	36.3
Smith's '99,	–	203.3	31.1
The June,	–	77.8	19.7
Twentieth Century,	Aug. 20,	214.7	42.5
White Giant,	Aug. 20,	230.3	8.3

Among these varieties it will be seen that ten give a yield at the rate of over 250 bushels of merchantable tubers per acre. These, mentioned in the order of productiveness, are as follows: Beauty of Hebron (first generation from Maine seed), 315.3 bushels; Beauty of Hebron (second generation from Maine seed), 298.7 bushels; I. X. L., 298.7 bushels; Steuben, 297.7 bushels; Early Nancy, 273.8 bushels; Million Dollar, 265.5 bushels; Ensign Bagley, 262.4 bushels; Early Rose, 258.2 bushels; Gem of Aroostook, 258.2 bushels; Daughter of Early Rose, 256.2 bushels.

Six varieties, as will be seen, gave yields at the rate of between 100 and 200 bushels per acre. These, mentioned in the order of least productiveness, are the following: Stevens, 148.3 bushels; Livingston, 161.8 bushels; All the Year Round, 165. 9 bushels; Early Carmen, 170 bushels; Honoeye Rose Seedling, 177.4 bushels; Early Pioneer, 185.7 bushels. Three varieties have given yields at the rate of under 100 bushels merchantable tubers per acre, viz.: Smith's Six Weeks, 65.3 bushels; Ford, 73.5 bushels; The June, 77.8 bushels. The last three varieties would seem beyond a doubt to be very inferior in productive capacity, and probably not worth cultivation. The varieties giving yields at the rate of between 100 and 200 bushels to the acre are, with one exception, well above 150 bushels; and, although giving much below the average yield for this season, they cannot be unreservedly condemned for lack of productiveness.

It may be remembered that in every test of varieties which has been made by this department of the Hatch Experiment Station the Beauty of Hebron and the Early Rose have been included. They have always ranked high in productiveness. This year it will be noticed that the Beauty of Hebron (first generation from Maine-grown seed) stands at the head, that the second generation from Maine-grown seed is next (although equalled by one other variety), and that the Early Rose is only seventh in the list. These facts constitute a striking commentary upon the claims which are usually made for new varieties. It is firmly believed that it is much wiser that potato growers shall secure seed of standard varieties grown and stored under the best conditions, than to pay high prices for new varieties, which in so many instances when carefully tested under the fairest possible conditions are found not to equal the older sorts either in productiveness or in quality. In our experience seed grown in northern Maine has invariably been found to be superior to that of our own production, even in the first generation. The Maine seed gives the larger yield, and the crop is somewhat earlier. It usually costs somewhat more than home-grown seed, but it is richly worth the greater price.

XIV. — Poultry Experiments.

In our experiments with poultry during the past year we have confined our attention almost exclusively to questions connected with the feeding of fowls for eggs. The principal question upon which we are striving to obtain light relates to the proper relation between the different nutrients in the ration fed; or, in other words, it is a question of the best nutritive ratio. During the past year our work has been as follows: —

1. We have compared two rations in one of which corn is prominent, in the other wheat, using beef scraps as the source of animal food, the nutritive ratios being: for the ration including corn, from 1 : 4.25 — 4.74; and in the ration in which wheat is prominent, 1 : 6.25 — 6.45.

2. We have compared two rations in which respectively corn and wheat are prominent, with milk albumin as the source of animal food. The nutritive ratio of the ration including wheat has been varied from 1 : 4 — 4.48; for the ration including corn, from 1 : 4.95 — 6.05.

3. We have compared two rations in one of which buckwheat is prominent, in the other corn, with milk albumin as the source of animal food. The nutritive ratio of both these rations has been rather wide, — from about 1 : 5.5 — 6.08.

The most important points to be noted in connection with the results are as follows: —

1. In the comparison of wheat with corn, where beef scraps are the source of animal food, the egg production has been good and nearly equal on the two rations, although the hens receiving the wheat ration have been somewhat the most productive.

2. In the comparison of wheat with corn, with milk albumin as the source of animal food, the egg production has been less satisfactory, and the hens which have received the corn ration have been the more productive.

3. In the comparison of buckwheat and corn, with milk albumin as the source of animal food, the egg yield has been rather small, with the advantage decidedly in favor of the corn.

It may be remembered that, in experiments carried out in 1899 and reported in our annual report for 1900, the comparisons between corn and wheat gave results decidedly in favor of the corn. A similar line of inquiry was continued during the years 1900 and 1901. A number of comparisons were made during these years between rations respectively rich in wheat and in corn, in connection with which in all cases beef scraps were used as the source of animal food. In the experiments of these two years, as in the experiment for this year, where beef scraps are used as the source of animal food the yields are slightly in favor of the wheat. It is not believed that we are yet in position to account for the difference in results made evident by the statements just given; but it is thought that a possible explanation is offered by the fact that in the tests comparing wheat and corn in 1899 animal meal was used as the source of animal food. The principal differences between such animal meal as we have employed and beef scraps are, that the animal meal contains the more mineral matter (undoubtedly derived from bone) and less fat than the scraps. It is the latter point especially which is believed to be significant. Corn is rich in fat; wheat is relatively poor in that constituent. With animal meal as a source of animal food, corn gave the best results. It has given the best results this year where milk albumin (which is still lower in fat than animal meal) is used as the source of animal food. And again, although this is less significant because buckwheat and corn differ from each other in marked degree in the amount of fibre they contain, we find the corn when compared with buckwheat, which is relatively low in fat, with milk albumin as the source of animal food, gives much superior results. It is fully recognized that the conditions determining the egg yield from a flock are numerous, and that the relation between the different nutrients in the rations fed is only one, and possibly by no means the most important, of these conditions. It is, however, believed that the question of the proper combination of nutrients has its importance. It is recognized that the problems arising are difficult; but the investigations will be continued, in the full belief that the results of faithful work will prove of ultimate value.

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OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

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APPROVED BY

THE STATE BOARD OF PUBLICATION.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

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——— ———	*Assistant Horticulturist.*
——— ———	*Assistant Horticulturist.*
FRED. F. HENSHAW,	*Observer.*

The co-operation and assistance of farmers, fruit-growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

The following bulletins and reports are still in stock, and can be furnished on demand: —

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.

No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 54. Fertilizer analyses.
No. 57. Fertilizer analyses.
No. 64. Analyses of concentrated feed stuffs.
No. 67. Grass thrips; treatment for thrips in greenhouses.
No. 68. Fertilizer analyses.
No. 69. Rotting of greenhouse lettuce.
No. 70. Fertilizer analyses.
No. 72. Summer forage crops.
No. 75. Fertilizer analyses.
No. 76. The imported elm-leaf beetle.
No. 77. Fertilizer analyses.
No. 78. Concentrated feed stuffs.
No. 79. Growing China asters.
No. 81. Fertilizer analyses; treatment of barnyard manure with absorbents; trade values of fertilizing ingredients.
No. 82. Orchard management; cover crops in orchards; pruning of orchards; report on fruits.
No. 83. Fertilizer analyses.
No. 84. Fertilizer analyses.
No. 85. Concentrated feeds.
No. 86. Orchard treatment for the San José scale.
No. 87. Cucumbers under glass.
No. 89. Fertilizer analyses; ash analyses of plants; instructions regarding sampling of materials to be forwarded for analysis.
No. 90. Fertilizer analyses.
No. 91. Injuries to shade trees from electricity.
No. 92. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Special bulletin, — The coccid genera Chionaspis and Hemichionaspis.
Technical bulletin, No. 1, — Greenhouse Aleyrodes; strawberry Aleyrodes.
Index, 1888–95.
Annual reports for 1897, 1898, 1899, 1900, 1901, 1902, 1903.

Of the other bulletins, a few copies remain, which can be supplied only to complete sets for libraries.

ANNUAL REPORT

OF GEORGE F. MILLS, *Treasurer* OF THE HATCH EXPERIMENT STATION OF MASSACHUSETTS AGRICULTURAL COLLEGE,

For the Year ending June 30, 1903.

Cash received from United States Treasurer,		$15,000 00
Cash paid for salaries,	$6,829 37	
for labor,	3,216 52	
for publications,	860 08	
for postage and stationery,	360 32	
for freight and express,	130 65	
for heat, light, water and power,	355 77	
for seeds, plants and sundry supplies,	810 76	
for fertilizers,	716 85	
for feeding stuffs,	587 17	
for library,	56 18	
for tools, implements and machinery,	196 13	
for furniture and fixtures,	35 03	
for scientific apparatus,	87 90	
for travelling expenses,	105 50	
for contingent expenses,	121 00	
for building and repairs,	530 77	
		$15,000 00

Cash received from State Treasurer,	$11,200 00	
from fertilizer fees,	4,215 25	
from farm products,	2,298 12	
from miscellaneous sources,	3,291 04	
		$21,004 41
Cash paid for salaries,	$10,303 59	
for labor,	2,446 47	
for publications,	353 03	
for postage and stationery,	254 39	
for freight and express,	45 41	
Amount carried forward,	$13,402 89	

Amount brought forward,	$13,402 89	
Cash paid for heat, light, water and power,	605 03	
for chemical supplies,	1,025 44	
for seeds, plants and sundry supplies,	378 43	
for fertilizers,	14 38	
for feeding stuffs,	700 36	
for library,	27 91	
for tools, implements and machinery,	39 54	
for furniture and fixtures,	1 50	
for scientific apparatus,	195 41	
for live stock,	61 45	
for travelling expenses,	694 94	
for contingent expenses,	245 86	
for building and repairs,	412 71	
Cash on hand,	3,198 56	
		$21,004 41

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ended June 30, 1903; that I have found the same well kept and classified as above; and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000, and the corresponding disbursements $15,000; for all of which proper vouchers are on file and have been by me examined and found correct, thus leaving no balance in the treasury.

CHARLES A. GLEASON,
Auditor.

AMHERST, Sept. 2, 1903.

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

The close of the present year completes a period of fifteen years of meteorological observations at this station. From the records obtained during this time the mean values of the several weather elements for each month have been computed, and the results will be used as the normals of this station for the purpose of comparison. Charts showing the more important meteorological data are being prepared for the exhibit of this division at the St. Louis Exposition.

Last year, when this station arranged to furnish the United States Weather Bureau with the usual voluntary observer's records, the advisability of changing our times of observation from 7 A.M., 2 P.M. and 9 P.M. to 8 A.M. and 8 P.M., to conform to the times of observation at other stations, was considered, and it was thought best not to make the change at that time. Our printed forms for permanent record being all used, it was thought best to provide for the above change in preparing new record books. This has accordingly been done, and the change from tri-daily to semi-daily observations will be made at the close of a five-year period, on Jan. 1, 1904. The records being largely controlled by our self-registering instruments, the change should not appreciably affect our results for comparison with the normals already deduced.

The usual 4-page bulletins, giving the more important daily records, with the monthly means and summary of the weather, have been issued the first of each month. An annual summary will be prepared and published as a part of the December bulletin.

The local forecasts sent out by the New England section of the United States Weather Bureau have been received during the year, and the signals displayed from the flagstaff on the tower. These forecasts having come this year by the Postal Telegraph and Cable Company, instead of the Western Union Telegraph Company, as formerly. Our telegraph line to the college has been out of service most of the year, and the predictions have been obtained by telephone, causing considerable inconvenience and delay in displaying the signals. Arrangements were finally made with the Postal Company, whereby they connect with our line to the college at the corner of Amity Street and Lincoln Avenue, they maintaining a line from their office to that point, and this division controlling the line from that point to the tower. The receipt of the forecasts by telegraph at the tower was resumed about December 1.

At the request of the section director of the Weather Bureau, the weekly snow reports are being sent to the Boston office, as in previous years.

Two standard thermometers, reading to one-fifth degree F., were purchased during the year, to replace others broken in use. Three new clocks for the Draper instruments in the tower were also bought, to replace others that were worn out.

REPORT OF THE BOTANISTS.

G. E. STONE AND N. F. MONAHAN, ASSISTANT.

Besides the general correspondence work relating to the diseases of plants, which is constantly increasing each year, this division has continued its usual experimental work in the greenhouse on various market garden and floricultural problems.

During the past year this division has published two bulletins, entitled, "Cucumbers under Glass," issued as Bulletin No. 87; and "Injuries to Shade Trees from Electricity," which was issued as Bulletin No. 91.

From the pathologist's point of view, the past season has shown some resemblance to the preceding one. Both seasons have been peculiar, as demonstrated by the second blossoming of a large number of plants and the general upsetting of their seasonal habits. There has been an absence of some fungi, which usually occur more or less commonly, and a predominance of others which generally do not cause much damage. Some indications of the pink mold, a so-called attendant of apple scab, which made its appearance last year for the first time in this State, has shown itself again, although trouble from this fungus has not been serious in this State. The sooty mold of greenings, etc., has been unusually abundant the past two years where spraying has not been properly attended to, causing much disfiguration of the fruit. Considerable damage was done to pear trees by lice, which profusely secreted honey dew on the foliage and stems, thereby furnishing conditions for the luxurious development of a black mold on the stems and leaves, causing much injury to the latter.

The raspberry cane blight, recently described by Prof. F. C. Stewart,[1] has been noted in this State, and specimens have been sent to Professor Stewart, who has reported upon them. How common this disease is, or is likely to become, we are at present not able to say. There has been, moreover, an unusual amount of winter-killing of raspberry canes, resulting from the unusual conditions of the fall of 1902.

Some complaint has been made in regard to a potato stem rot, a disease which is apparently more common in Vermont, where it, with other potato diseases, is receiving serious attention by Prof. L. R. Jones.

An unusual leaf spot disease for this region was noted on corn. This was caused by the fungus *Helminthosporium inconspicuum* C. and E., which gave the leaves a badly spotted appearance, and in one instance rendered the crop practically useless. Probably the extremely abnormal corn weather during the past summer was responsible for this.

A fungus known as *Vermicularia trichella* Fr. caused considerable spotting and damage to the leaves of the English ivy (*Hedera helix*, L.). There has been a minimum number of the usual shade tree fungous blights, although the blight of the horse-chestnut leaves, caused by the fungus *Phyllosticta sphæropsoidea* Ell. and Ev., was troublesome, and a considerable amount of defoliation occurred to maples from sun scorch. The Norway maple leaves were also greatly lacerated by the winds at the time of unfolding, and they were literally covered with honey dew, which in some cases resulted in the development of a black mold on them.

The stem rot diseases of the carnation, aster, campanula, etc., have been rather common on out-of-door plants. The usual blights of the melon and cucumber were present, but these crops did so poorly that the fungus had little material to work on. The general consensus of opinion among growers of melons and cucumbers is that spraying does little or no good when the anthracnose and alternaria are present. This is especially true of the melon, where all attempts at spraying, even when frequently attended to, failed to hold these fungi in check.

---

[1] Geneva, N. Y., Experiment Station, Bulletin No. 226, December, 1900.

The most general complaint, however, during the spring and summer, was in regard to winter-killing. It is seldom one finds so many varieties of plants injured from this cause, which can be traced back to the unusually prolonged warm weather, characteristic of the fall of 1902, and the sudden freeze following in early December. Among the plants that have suffered to a considerable extent are the following: —

The Californian privet (*Ligustrum ovalifolium*) and *Ligustrum ibota* were in many cases killed outright. Yellow and crimson rambler roses and certain honeysuckles were killed to the ground. The climbing ivy (*Ampelopsis veitchii*) was badly damaged, so much so, in fact, that buildings that were tolerably well covered with this beautiful ivy were almost bare in mid-summer. Wistarias, deutzia, spiræa thunbergii, spiræa vanhouttei and forsythia had their flower buds injured so severely that they made little show in the spring. The Japanese clematis was in most cases killed to the ground. Euonymus radicans suffered badly, as did many of the viburnums. Many of the choicer aquilegias were killed outright. The fruit buds of cherries, peaches and Japanese plums were practically killed; in some cases the wood was much injured. Grape vines were in some cases killed to the ground, and strawberries, blackberries and raspberries were much injured. Such wild plants as the beech, plum and buckthorn, and many of the wild roses, had their wood severely injured. Many of these plants appeared to come through the winter successfully, and threw out strong shoots in the spring, when they suddenly collapsed. Blackberries and raspberries showed a marked tendency to die back after having blossomed and fruited. In some other instances plants not supposed to be hardy, such, for example, as the crimson clover and alfalfa, have gone through the winter without trouble. It would appear that, while the severe frost in December, following the unusually prolonged warm spell, was the means of doing great injury to plants that are supposed to be tolerably hardy, those like the crimson clover, etc., which are not hardy, were not affected. The limited amount of frost in the ground, due to the snow cover, eventually proved advantageous to such plants as the crimson clover and alfalfa. It is probable that the unusually slight amount of moisture present in the soil during the past spring had much to do with weakening many plants which might have made some recovery under other conditions.

We append to this report some experiments relating to the influence of electricity on the growth of plants, which have been carried on by us and students in a minor way for some years. Notwithstanding the considerable accelerated growth that electrical stimulation is capable of giving rise to, these experiments are not presented with any idea in mind that they furnish evidence of legitimate lines of forcing, or that the matter will be taken up by practical growers as a means of increasing their crops, especially at the present time. There are many legitimate lines of increasing and improving crops of which growers have not as yet made full use, and, so long as such exist, the wisest policy to pursue is to pay little attention to the so-called freak farming methods. This subject is, moreover, an especially complicated one, and it is a question whether it would be of much value to those who are following commercial methods, even if considerable gain could be obtained. All stimuli to plants are by no means advantageous from the commercial point of view, inasmuch as they do not always induce acceleration in the right direction, since the law of correlation holds good in the plant kingdom, as elsewhere. Whether the scarcity of forcing elements or the development of more refined methods of the gardening of the future will induce gardeners to utilize the various cosmic forces which act as stimuli, and which are not employed at the present time, remains to be seen.

THE INFLUENCE OF CURRENT ELECTRICITY ON PLANT GROWTH.

BY G. E. STONE.

Since 1747, when Dr. Mainbray of Edinburgh electrified two myrtle plants, various experiments have been made to test the effects of electricity on the growth of plants. Many marvelous results have been reported from time to time that have arisen from electrical treatment, and, as a rule, the more ignorance the experimenter displayed in his knowledge of plant physiology, the more startling and marvelous have been the results.

At the time our experiments were undertaken we were unable to find instances where any attempt had actually been made to study, in a methodical way, the influence of current electricity on plants; and in practically all of the previously recorded experiments the data were scant and the scope of the work was extremely limited. In the various haphazard results that had been reported from time to time there had been no attempt made to measure the current or resistance, or to ascertain the electro motive force employed in any of the experiments from which remarkable deductions had been drawn. One of the criticisms which can be made in regard to all of the earlier work, as well as most of the later work, is that, with a very few exceptions, only a few plants were employed in experimenting, — frequently only one or two. As a consequence, the errors arising from individual variation were entirely ignored, since enough plants were not employed to eliminate them. Indeed, in numerous cases the results obtained were nothing more than would be obtained from individual variation, or would naturally arise from a slight difference in environment. The limited amount of current which we have shown to act as a stimulus to plant growth would indicate that in some cases they were not in the range of acceleration (see Fig. 1). That plants respond to electrical stimuli in various ways is well known. The effect, however, which electricity has upon the growth of plants has not been well understood, and the results obtained by various experiments have not been convincing, for reasons already pointed out. The fact has been definitely established that electrical currents exist in the soil, and also in the plant; in fact, wherever chemical activity occurs electric currents are likely to be present, although these currents may be comparatively insignificant, and require delicate instruments for their detection.

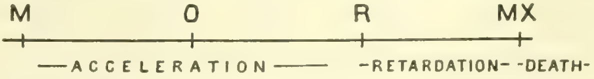

FIG. 1.—Diagram showing range of electric current affecting plants. M, minimum; O, optimum, or current producing greatest stimulus; MX, maximum, or death current; R to MX, retardation current.

The following experiments in stimulating plants with electricity have been carried on in this department for some years, and previous to undertaking this work many thousands of plants have been experimented with, and the minimum, optimum and maximum currents have been established by us in a general way. We therefore had more or less a definite idea in mind as to what strength of current we wished to apply at the beginning of our work. The experiments we are about to describe, therefore, represent only a small part of those which we have made, and these were made under conditions resembling those employed for commercial purposes. We shall, however, interpret the results of these experiments in the light of those obtained from our long study given to the subject, rather than from what these particular tables show.

The work was carried on in the greenhouse, during the summer months. The plants utilized were radishes and lettuce, which were selected for special reasons as being suitable for our work. The plants were grown in wooden boxes, 53 inches long, 32 inches wide and 7 inches deep. These boxes were placed on movable trucks, or in some cases on supports 18 inches from the floor. In all cases they were insulated. The soil employed was of a uniform quality and texture, and has been used for these experiments alone for some years. Previous to using the soil it was sifted through a sieve of $\frac{3}{8}$-inch mesh, and thoroughly mixed. After using the soil for a few experiments, it was taken out, resifted and thoroughly incorporated again; and occasionally the boxes were shifted about, that is, the normal or untreated boxes were substituted or changed for those which had been treated. With a few exceptions, copper or zinc plates were used for electrodes. These were made the same size as the ends of the boxes, and in a few exceptional cases two series of wires, strung on a frame about three inches apart, were employed instead of the plate electrodes. One of these frames of wires was buried near the surface, the other being buried near the bottom of the box. The current, therefore, had to pass from one frame to the other in a vertical direction through the soil. The strength of the currents was in most cases obtained with the aid of a Weston milammeter, capable of reading $\frac{1}{20}$ of a milliampere, or about $\frac{1}{20000}$ of an ampere. The interrupted induced currents were estimated, and represent only approximate determinations.

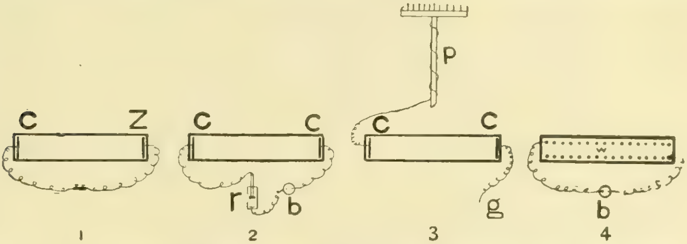

FIG. 2. — Longitudinal section of boxes employed in the electrical experiments, showing different methods of treatment. Size of boxes, 53 by 32 by 7 inches. 1, copper and zinc electrodes connected; 2, direct current with rheostat; 3, atmospheric; 4, wire electrodes. C, copper electrodes; Z, zinc electrodes; r, rheostat; b, gravity cells; w, wires; g, ground wire; p, collecting pole, 47 feet high.

In the radish experiment the seed was sown directly in the treated boxes, whereas in the case of the lettuce the plants were transplanted into the treated boxes when of suitable size to make good growth; the latter plants, therefore, were not stimulated during the whole period of development. Gravity cells were used in all cases except with the interrupted induced current, in which case sal-ammoniac cells were employed.

EXPERIMENTS WITH RADISHES.

TABLE I. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus* L.). *Normal Plants taken as the Standard at 100.*

[Duration of experiment, 38 days.]

No.	TREATMENT.	Number of Plants.	AVERAGE WEIGHT, IN GRAMS, OF —		PER CENT. GAINED IN WEIGHT OF —		Total Per Cent. gained.
			Roots.	Tops.	Roots.	Tops.	
	Average of three normals, .	112⅔	4.83	10.55	-	-	-
1	Direct current; one gravity cell; copper plate electrodes, ...	81	4.89	12.58	.012	19.24	13.60
2	Direct current; three gravity cells; wire electrodes, .	110	4.63	9.26	[1]4.140	[1]12.22	[1]9.68
3	Interrupted induced current; copper plate electrodes, .	114	5.85	11.22	21.110	6.35	10.98

[1] Loss.

Total average weight, in grams: —	Normal.	Treated.	Per Cent. gained.
Of roots, ...	4.83	5.12	6.00
Of tops, ...	10.55	11.02	4.45
Of whole plant, ...	15.38	16.14	4.93

In Table I., in which six experiments are shown, three normal and three treated, the results are not in every way satisfactory. The current strengths were determined only once or twice in each instance, and these were estimated by means of the electro-motive force of the cell and resistance of the soil, and also by a milammeter. The current strengths given, therefore, represent only those which were found at the time of the measurements; and, since the resistance of soil is constantly changing with the movements of the water currents and with the ever-changing moisture conditions, due to watering, the figures giving strengths of current must not be considered as averages. The strengths of current employed in the experiments shown in the first five tables vary, probably from .05 to 1 milliampere.

In the interrupted induced current experiments the current had a duration of only about ten seconds per hour. This was accomplished with a clock arrangement and with a Du Bois-Reymond induction apparatus. It should be pointed out, however, that with the use of this apparatus only approximate current strengths can be obtained, as it does not constitute a particularly favorable type of instrument for obtaining uniform currents of a definite strength. Our extensive use of the apparatus in other work has enabled us, nevertheless, to use it with some degree of certainty of securing optimum strengths of current. The three gravity cells with wire electrodes apparently furnish too much current, hence we obtained a loss with these. We were beyond the optimum and in the retardation zone (see Fig. 1). This method of applying current was not considered a satisfactory one, and it was subsequently abandoned.

Nos. 1 and 3 showed a gain in both roots and tops, the total gain being 13.60 and 10.98 per cent. respectively. At the bottom of the table is given the total gain from electrical treatment; for example, the weights of the plants from three treated boxes are compared with the weights of those in the three normal boxes. The total gain of 4.93 per cent. is of little significance.

TABLE II. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus* L.). *Normal Plants taken as the Standard at 100.*

[Duration of experiment, 39 days.]

No.	TREATMENT.	Number of Plants.	AVERAGE WEIGHT, IN GRAMS, OF —		PER CENT. GAINED IN WEIGHT OF —		Total Per Cent. gained.
			Roots.	Tops.	Roots.	Tops.	
	Average of three normals, .	220⅔	5.29	5.55	–	–	–
4	Direct current; one gravity cell; copper plate electrodes, ...	205	6.22	12.65	17.58	127.92	74.07
5	Direct current; one gravity cell; wire electrodes, . .	250	5.88	7.47	11.15	34.59	23.15
6	Amospheric electricity; copper plate electrodes, . .	180	6.60	10.06	24.76	81.26	53.61
7	Copper and zinc plate electrodes, connected, . .	109	14.01	16.61	164.84	199.28	182.28
8	Interrupted induced current; copper plate electrodes, .	220	6.17	6.17	16.63	11.17	13.83

Total average weight, in grams: —	Normal.	Treated.	Per Cent. gained.
Of roots, ...	5.29	7.77	46.88
Of tops, ...	5.55	10.59	90.85
Of whole plant, ...	10.84	18.36	69.54

In Table II. is shown a similar series of experiments, with modifications in the strengths of currents and methods of treatment. The currents, however, are reduced in all instances with favorable results. Nos. 6 and 7 received different treatment from those shown in the preceding table. In No. 6, termed atmospheric electricity, the current was obtained from a pole 35 feet above the ground ; from the top of this pole there projected 24 small copper points, distributed in two circles, the outer arc having a radius of 30 inches. The arrangement was similar to that shown in Fig. 2, but not identical. The copper points were all connected with a single wire leading to the copper plate electrode of Box No. 3, the other electrode being grounded, as shown at G. The electrical potential was not determined in this experiment, but the deflection of the needle of a sensitive galvanometer showed that a current was present in the soil.

In No. 7, copper and zinc plate electrodes were simply connected together with a wire ; this formed a cell in itself, and generated a current, usually about the optimum, which could be readily read with the milammeter. The results of the experiments are shown in the last column at the bottom of the table.

TABLE III. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus L.). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 36 days.]

No.	TREATMENT.	TOTAL WEIGHT, IN GRAMS, OF—		PER CENT. GAINED IN WEIGHT OF—		Total Per Cent. gained.
		Roots.	Tops.	Roots.	Tops.	
	Normal,	700	2,700	-	-	-
9	Direct current; one gravity cell; copper plate electrodes,	800	2,900	14.28	7.40	8.82
10	Amospheric electricity; copper plate electrodes,	900	3,000	28.59	11.11	14.70

Total weight, in grams:—	Normal.	Treated.	Per Cent. gained.
Of roots,	700	850	21.42
Of tops,	2,700	2,950	9.25
Of whole plant,	3,400	3,800	11.76

TABLE IV. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus L.). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 38 days.]

No.	TREATMENT.	Number of Plants.	AVERAGE WEIGHT, IN GRAMS, OF —		PER CENT. GAINED IN WEIGHT OF —		Total Per Cent. gained.
			Roots.	Tops.	Roots.	Tops.	
	Normal,	291	3.09	2.74	–	–	–
11	Direct current; one gravity cell; copper plate electrodes,	294	2.65	2.72	[1] 14.23	[1] .72	[1] 7.89
12	Atmospheric electricity; copper plate electrodes,	281	3.20	4.27	3.55	55.83	28.13
13	Copper and zinc plate electrodes, connected,	289	2.94	5.53	[1] 4.85	101.82	45.28

Total average weight, in grams: —	Normal.	Treated.	Per Cent. gained.
Of roots,	3.09	2.93	[1] 5.50
Of tops,	2.74	4.17	52.19
Of whole plant,	5.83	7.10	21.78

[1] Loss.

TABLE V. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus L.). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 40 days.]

No.	TREATMENT.	Number of Plants.	AVERAGE WEIGHT, IN GRAMS, OF —		PER CENT. GAINED IN WEIGHT OF —		Total Per Cent. gained.
			Roots.	Tops.	Roots.	Tops.	
	Normal,	273	3.29	4.02	–	–	–
14	Direct current; one gravity cell; copper plate electrodes,	275	4.00	4.18	21.58	3.98	11.90
15	Atmospheric electricity; copper plate electrodes,	277	3.61	3.97	9.72	[1] 1.24	3.69
16	Copper and zinc plate electrodes, connected,	278	3.74	3.95	13.67	[1] 1.74	5.19

[1] Loss.

Total average weight, in grams: —	Normal.	Treated.	Per Cent. gained.
Of roots,	3.29	3.78	14.86
Of tops,	4.02	4.03	.02
Of whole plant,	7.31	7.81	6.84

The experiments shown in tables III., IV. and V. followed one another in succession, and were conducted in a similar manner. Some of the data shown in Table III. was unfortunately mislaid or lost, hence it is incomplete.

No. 11, in Table IV., shows a loss, but the average percentage gained by treatment in other cases is important. The gain shown in Table V. as a result of treatment is comparatively small.

TABLE VI. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus* L.). *Normal Plants taken as the Standard at 100.*

[Duration of experiment, 30 days.]

No.	TREATMENT.	Number of Plants.	Average Current, in Milliamperes.	AVERAGE WEIGHT, IN GRAMS, OF — Roots.	AVERAGE WEIGHT, IN GRAMS, OF — Tops.	PER CENT. GAINED IN WEIGHT OF — Roots.	PER CENT. GAINED IN WEIGHT OF — Tops.	Total Per Cent. gained.
	Normal, . . .	241	–	5.1	3.2	–	–	–
17	Direct current; one gravity cell; copper plate electrodes, .	215	.10 (.05–.24)	6.1	4.1	19.60	28.12	22.88
18	Direct current; two gravity cells; copper plate electrodes,	242	.43 (.22–.90)	5.9	5.5	15.68	71.87	37.34
19	Copper and zinc plate electrodes, connected, . . .	198	–	7.4	5.2	45.09	62.50	51.80

Total average weight, in grams: —	Normal.	Treated.	Per Cent. gained.
Of roots, ...	5.1	6.46	26.66
Of tops, ...	3.2	4.93	54.06
Of whole plant, ...	8.3	11.39	37.22

TABLE VII. — *Showing the Effect of Current Electricity upon the Growth of Radishes (Raphanus sativus* L.). *Normal Plants taken as the Standard at 100.*

[Duration of experiment, 36 days.]

No.	TREATMENT.	Number of Plants.	Average Current, in Milliamperes.	AVERAGE WEIGHT, IN GRAMS, OF — Roots.	AVERAGE WEIGHT, IN GRAMS, OF — Tops.	PER CENT. GAINED IN WEIGHT OF — Roots.	PER CENT. GAINED IN WEIGHT OF — Tops.	Total Per Cent. gained.
	Normal, . . .	217	–	10.80	4.14	–	–	–
20	Direct current; one gravity cell; copper plate electrodes, .	264	.197 (.10–.33)	12.30	6.60	13.88	59.42	26.50
21	Direct current; two gravity cells; copper plate electrodes, .	292	.516 (.23–1.0)	12.20	7.50	12.96	81.16	31.19
22	Copper and zinc plate electrodes, connected, . . .	272	.305	11.20	4.96	3.71	19.80	8.16

Total average weight, in grams: —	Normal.	Treated.	Per Cent. gained.
Of roots, ...	10.80	11.90	10.18
Of tops, ...	4.14	6.35	53.14
Of whole plant, ...	14.94	18.25	22.15

The concluding experiments with radishes are shown in tables VI. and VII. In this series the atmospheric experiments were omitted, and two direct current experiments were run in each series, in which different strengths of currents were employed. In these experiments, and all others which follow, an attempt was made to regulate more carefully the current strengths, and to make daily readings of the same. For this purpose a water rheostat was introduced in the circuit in the two direct current experiments; this enabled us to modify resistance, and to maintain a tolerably uniform current throughout. Current records in all the remaining radish experiments are averages for the whole period, and are based on four readings each day. The minimum and maximum currents are given in parentheses. In the direct current series we endeavored to maintain .2 and .4 milliamperes respectively. In No. 17, however, it only averaged .1 milliampere; in Nos. 19 and 22 readings were made every three days, but no attempt was made to modify the current strengths, inasmuch as these boxes generally maintained the desired current.

The results shown in these tables are more uniform than in the preceding ones, as might be expected from the greater care we gave in maintaining a more or less uniform stimulus. No loss is shown by the treated ones; on the other hand, there is considerable acceleration shown by treatment.

SUMMARY. — *Showing the Results with Radishes (Raphanus sativus* L.) *given in Tables I., II., IV.–VII.*

TREATMENT.	Number of Plants.	PER CENT. GAINED IN WEIGHT OF —		Total Per Cent. gained.
		Roots.	Tops.	
Direct current (weak); copper plate electrodes; Nos. 1, 4, 11, 14, 17, 20,	1,334	9.73	39.66	23.67
Direct current (stronger); copper plate electrodes; Nos. 18, 21,	534	14.32	76.51	34.26
Direct current; wire electrodes; Nos. 2, 5,	360	3.50	11.18	6.73
Interrupted induced current; copper plate electrodes; Nos. 3, 8,	334	18.87	8.76	12.40
Copper and zinc plate electrodes, connected; Nos. 7, 13, 16, 19, 22,	1,146	44.49	76.33	58.56
Atmospheric electricity; copper plate electrodes; Nos. 6, 12, 15,	738	12.67	45.28	28.47

Average per cent. of weight gained, in grams: —

Of roots,	17.26
Of tops,	42.95
Of whole plant,	27.34

The results of electrical treatment of various kinds and of different strengths of currents, in which 3,446 treated radish plants were compared with 2,022 normal or untreated ones, are shown in the summary. These comparisons are based on the growth of the normal plants with which the treated were grown, and not on the total normals, since the duration of experiments in one table does not correspond with those in another; or, in other words, there existed some difference in the degree of maturity of the various crops. This method of comparison is necessary, since the treatment varied in time, and the experiments in each table were not parallel throughout. The results show, however, appreciable gains; and, as they are averages, the percentages represent more accurately the influence of electrical treatment, the total gain for roots and tops being 27.34 per cent. A notable feature is seen in acceleration of tops, which showed about two and a half times more growth than that shown by the roots. In the case of the two interrupted induced-current experiments the reverse holds true, there being more than twice as much growth of roots as tops. This current exerts a different physiological effect on plants than the direct current.

Experiments with Lettuce.

The tendency of electrical stimuli to accelerate the growth of the tops of radish plants more than the roots suggested the idea of substituting lettuce. Lettuce possesses a different and more desirable habit of growth, it would seem, for electrical stimulation. The variety of lettuce grown in all cases was that known as the Boston head type, so commonly used by market gardeners in Massachusetts. The plants were grown according to the customary manner of growing lettuce; namely, the seed was sown in a small box of soil. When the seedlings were an inch or two high they were transplanted into larger boxes containing loam; and when they had formed three or four leaves two or three inches long, they were carefully selected, as regards vigor and size, and transplanted into the experimental boxes, as in the radish experiments. The loam in which they were started was of uniform quality and similar texture to that used in the boxes. Twenty-four plants were set in each box, which allowed room for their full development. In transplanting, however, there was little or no loam attached to their roots. We have handled lettuce so extensively in our greenhouse that we were familiar with its characteristic requirements, and usually had on hand an ample supply of material from which to select. The strengths of currents in all lettuce experiments where gravity cells were used are based on four daily records. The minimum and maximum currents are also given in parentheses in all cases. In the copper and zinc electrode connections the currents were recorded every three days and the tables show the averages obtained.

TABLE VIII. — *Showing the Effect of Current Electricity upon the Growth of Lettuce (Lactuca sativa* L.*). Normal Plant taken as the Standard at 100.*

[Duration of experiment, 31 days.]

No.	TREATMENT.	Number of Plants.	Current, in Milliamperes.	Total Weight, in Grams, of Plants.	Average Weight, in Grams, of Plants.	Per Cent. gained in Weight.
	Normal, ...	23	–	798	34.69	–
23	Direct current; copper plate electrodes, ...	23	.183 (.05–.25)	1,233	53.60	54.22
24	Direct current; copper plate electrodes, ...	22	.395 (.15–1.0)	1,226	55.72	60.62
25	Copper and zinc plate electrodes, .	22	.286 (.1–.5)	1,126	51.18	47.53

Total average weight, in grams: —

Normal, ...	34.69
Treated, ...	53.50
Total per cent. gained, ...	54.22

TABLE IX. — *Showing the Effect of Current Electricity upon the Growth of Lettuce (Lactuca sativa* L.*). Normal Plants taken as the Standard at 100.*

[Duration of experiment, 42 days.]

No.	TREATMENT.	Number of Plants.	Current, in Milliamperes.	Total Weight, in Grams, of Plants.	Average Weight, in Grams, of Plants.	Per Cent. gained in Weight.
	Normal, ...	24	–	681	28.12	–
26	Direct current, ...	24	.199 (.10–.35)	818	34.08	21.19
27	Direct current, ...	24	.342 (.20–.50)	816	34.00	20.91
28	Copper and zinc plate electrodes, connected, ...	24	.296 (.05–.60)	725	30.20	7.39

Total average weight, in grams: —

Normal, ...	28.12
Treated, ...	32.73
Total per cent. gained, ...	16.39

In the two preceding tables are shown the results of electrical treatment upon lettuce. The current was set at .2 milliamperes in experiments 23 and 26, and at .4 milliamperes in experiments 24 and 27. The experiments in both tables show the effect of electrical treatment, and where the resistance was modified the results are tolerably uniform. The gain by all treatment is 16.29 and 54.52 per cent. respectively.

TABLE X. — *Showing the Effect of Current Electricity upon the Growth of Lettuce (Lactuca sativa* L.). *Normal Plants taken as the Standard at 100.*

[Duration of experiment, 50 days.]

No.	TREATMENT.	Number of Plants.	Current, in Milliamperes.	Total Weight, in Grams, of Plants.	Average Weight, in Grams, of Plants.	Per Cent. gained in Weight.
	Normal,	24	–	619	25.79	–
29	Direct current,	23	.171 (.02-.25)	575	25.00	3.06
30	Atmospheric electricity,	23	–	784	34.08	32.14
31	Copper and zinc plate electrodes, connected,	24	.06 (.01-.09)	688	28.66	11.13

Total average weight, in grams: —
Normal, ... 25.79
Treated, ... 29.24
Total per cent. gained, ... 13.37

TABLE XI. — *Showing the Effect of Current Electricity upon the Growth of Lettuce (Lactuca sativa* L.). *Normal Plants taken as the Standard at 100.*

[Duration of experiment, 60 days.]

No.	TREATMENT.	Number of Plants.	Total Weight, in Grams, of Plants.	Average Weight, in Grams, of Plants.	Per Cent. gained in Weight.
	Normal,	24	710	29.58	–
32	Direct current,	24	800	33.33	12.67
33	Copper and zinc plate electrodes, connected,	24	1,355	56.45	90.83
34	Atmospheric electricity,	24	1,000	41.66	40.83

Total average weight, in grams: —
Normal, ... 29.58
Treated, ... 43.81
Total per cent. gained, ... 48.10

Tables X. and XI. show experiments arranged similar to the two preceding tables, except that atmospheric electricity is substituted for one of the direct currents. The atmospheric experiments were conducted with some modification from those previously described with radishes. The principal difference, however, consisted in the pole being 47 feet from the ground, instead of 35 feet, and the number of copper points was 124, instead of 24. (See Fig. 2, No. 3.) In the latter case we also used a 28-inch metal bicycle wheel to support the points at the top of the pole; in the former arrangement an inverted umbrella frame was used. In No. 29 we endeavored to maintain a current of .2 milliamperes; Nos. 31 and 33 gave the usual current, but no attempt was made to obtain averages in the latter. A sensitive galvanometer usually showed a deflection of the needle when in circuit with the atmospheric electrodes; and when the wire from the pole was attached to a Thomson self-recording electrometer it was usually sufficient to deflect the needle and to charge slightly a glass case of 30 cubic feet capacity. Only occasional observations were made of the strength of the current in experiments shown in Table XI.

SUMMARY. — *Showing the Results with Lettuce (Lactuca sativa L.) given in Tables VIII.–XI.*

TREATMENT.	Number of Plants.	Average Current, in Milliamperes.	Total Per Cent. gained.
Direct current (weak); copper plate electrodes; Nos. 23, 26, 29, 32,	94	0.184	22.78
Direct current (stronger); copper plate electrodes; Nos. 24, 27,	46	0.367	40.76
Copper and zinc plate electrodes, connected; Nos. 25, 28, 31, 33,	48	0.214	36.48
Atmospheric electricity; copper plate electrodes; Nos. 30, 34,	47	–	39.22

Average per cent. of weight gained, in grams, ... 34.81

The average percentage of gain shown by lettuce is slightly higher than that given by radishes, although the acceleration is not so great as that shown in the growth of radish tops over roots. There are, however, no instances in the lettuce treatment where the normal plants have excelled in growth the treated ones, although in No. 21 there is a difference of only 3 per cent. between normal and treated.

Conclusions.

The foregoing experiments with lettuce and radish plants show, in all instances except two, a total gain by the use of electrical stimuli. Those experiments where an attempt was made to maintain a strength of current within narrow limits showed the best results from treatment. Could an absolutely definite strength of current be utilized throughout the period of duration much closer results could be obtained, and the optimum current be more closely determined. Such an arrangement suggested itself to us quite early in our work, but the necessary equipment was not at hand. Since the variations in current strength depend largely upon the variations in soil moisture, tolerably constant currents might be obtained by regulating the water supply ; but some automatic resistance appliance would undoubtedly constitute the best mechanism for getting absolutely constant currents. The effect which electricity has in accelerating the growth of plants and on the germination of seeds is positive ; and in hundreds of experiments, conducted in a different manner, we have seldom obtained any negative results. We have, moreover, conclusively shown from our experiments that the alternating current is much superior to the direct as a stimulator ; therefore the alternating-current experiments, Nos. 3 and 8, given in this series, should by no means be considered as typical, as we have apparently failed to get the optimum strength in these cases.

The question naturally arises, in what manner does electricity stimulate plants ; or, in other words, how are accelerated growth and accelerated germination to be explained? There are numerous agencies which act as stimuli to seeds and plants about which little is known in regard to how they stimulate the plant. There are, to be sure, many theories advanced for the purpose of explaining the response of plants to various stimuli.

We know perhaps as much about the rationale of electrical action on plants as we do about the effects of light in producing heliotropic bendings, or of gravity in producing geotropic bendings. Some of the various theories pertaining to electrical action, however, possess interest and are worthy of citation. Frecke held the idea that electricity was the great moving force of animate creation, and identical with nervous influence. Marat was of the opinion that electricity exerted a marked influence on the fertility of the soil, and similar ideas have been advanced by others in more recent times. Fichtner and Sohne claimed to have found that electricity rendered soluble the constituents of the soil; and the same opinion was advanced by Tschinkel, who believed that acceleration and growth were brought about by the action of electricity upon the salts and other constituents of the soil. Jodro attached a double function to the action of the soil current: first, it acts chemically on soil, in dissolving those constituents necessary for plant nourishment; and second it acts mechanically, in setting the particles of the soil into a state of molecular vibration, thus loosening the earth. These views relating to the decomposition of the certain salts in the earth by passing a current of electricity through it have not been confirmed by Wollny. He made a series of careful analyses of soil, electrically treated and untreated, and found absolutely no difference, which could be attributed to the effects of electricity, in the percentages of potassium, ammonia, phosphoric acid, potassium nitrate and carbonic acid gas. The action of electricity upon oxygen, as is well known, gives rise to ozone; and some botanists have believed that the production of ozone in the seed by electric currents is the prime factor in accelerating germination and growth.

Most of these theories are very fanciful, and all inadequately explain the stimulating effect of electricity upon plants, nor is there any reason to believe that this phenomenon can be explained by simple mechanical theories. There may exist a fundamental basis for the theory that electricity is capable of decomposing certain constituents of the soil and rendering them more available, but in all probability the strength of current which is capable of advantageously stimulating plants would produce little effect on the soil; at any rate, it would produce little effect during the short space of time it requires to mature most crops. Moreover, when it is considered that moist seeds and seedlings respond to electrical stimuli in quite a remarkable manner when sown and allowed to develop on moist filter-paper cloth or in porous clay dishes, etc., the complicated soil theory of electrical action falls to the ground.

Electricity affects the protoplasm of the plant, and it is to the effect on the protoplasm that we must look for the solution of the problem, and not to its influence on the soil. This can be seen in plants that show protoplasm movements, such as Chara, etc. It has long been known that weak currents stimulate protoplasm, and induce an accelerated movement; whereas strong currents retard or stop such movements, or, if too strong, they kill the protoplasm.

Current electricity likewise induces bendings in the roots (galvanotropism) when grown in water between electrodes. In such cases weak currents produce negative bendings, — that is, towards the cathode; while strong currents produce positive bendings, — towards the anode. Similar effects are seen in the movements exhibited by many microscopic animals, such as paramœcia and other protozoa.

Plants respond to light, gravity, moisture, etc., in a positive and negative manner; and it is also known that a negative electrotropic irritability exists in certain plants (Phycomyces in this case), or a sensitiveness to Hertz waves which induces negative bendings. The plant organism, whether in the embryonic or adult stage, responds in a positive and negative manner to various cosmic forces which act as stimuli. There is a positive geotropism which induces roots to grow downwards, and a negative geotropism which induces shoots to grow upwards. The force which accomplishes this is termed gravity. Our comprehension of gravity, however, is scarcely more intelligible than that of electricity, and for all we know they may be the same or similar manifestations of force. The results of electrical stimulation to plants are quite similar in their effects to those exhibited by other forms of stimuli.

There is a minimum, optimum and maximum current which gives rise to reactions similar to those obtained from other forms of stimuli. There is also a well-defined latent period, such as we find associated with heliotropic and geotropic stimuli, etc. Moreover, there exists a definite relationship between current intensity and perception, or reaction of the organism, as in chemotactic stimulation.

It was observed by early experimenters that there existed a difference in the growth of plants when subjected to what is termed positive and negative charges. Our limited experiments in this respect have shown that when seeds were treated with a positive charge the growth of the roots was greatly accelerated, while the stems were much less so ; and conversely, when treated with a negative charge, the stem showed a greater accelerated growth than the roots. Germination — that is, radical development — was greatly accelerated when seeds were charged positively, although when charged with a negative charge germination at first was much less accelerated than in untreated seed. Thus we have a positive charge stimulating organs which react in a positive manner, and a negative charge stimulating organs which react in a negative manner ; also the effect of a positive charge acting as a slight stimulus or retarding organs which act in a negative manner, and the negative only slightly stimulating or retarding positive reacting organs.

It would also appear as if positive charges had a tendency to produce attenuated or elongated root development. In regard to this point, it would be interesting to ascertain whether positive charges increase geotropic irritability. One of the recent conceptions of solutions is that they contain ions which are atoms or groups of atoms positively or negatively charged. It has been observed that solutions with a predominant positive charge, such as acids, and those with a predominant negative charge, bases and salts, have a certain definite effect upon protoplasm which is identical with those produced by positive and negative electrical stimulation. There is also reason to believe that protoplasm consists of particles which are charged positively and negatively. It is possible that in the protoplasm of roots and stems (hypocotyls, as well) of plants there exist opposite predominant charges, — the root carrying predominant negative charges, the stem predominant positive charges. When roots are stimulated with positive charges, acceleration results; and when stimulated with negative charges, acceleration is less marked. In other words, stimulation may arise by changing the predominant charge of the organ, and those organs respond most favorably to electrical stimuli in which opposite charges predominate. In subjecting roots to a positive charge, the predominant negative charges are overpowered or neutralized by the charges, and stimulation results; likewise, in subjecting stems to negative charges, the predominant positive charges are overpowered or neutralized by the negative charges, and stimulation likewise results; but reinforcing predominant positive or negative charges by electrical stimulation causes only a slight stimulus or retardation.

From these experiments it would appear that direct currents appear to stimulate most organs which possess predominant positive charges (radish tops), while interrupted induced currents appear to stimulate most organs which possess predominant negative charges. There is known to exist a difference between the "make" and "break." In the latter current, which is capable of giving rise to a modified physiological reaction, the effects of the opening are always more marked. The effects of the direct current noted above are not so readily accounted for on the basis of this theory.

These experiments have suggested other lines of investigation, and a further report will be made concerning them. It is possible that prolonged stimulation gives rise to different effects than brief stimuli. In prolonged stimulation with direct currents the positive electrode may have a toxic effect, causing inhibition, as is the case with solutions with positive ions. Physiologists have noted that the negative stimulates where the positive current prevents stimulation, although such does not hold in the case of plants, at least when charges of a brief duration are employed.

THE INFLUENCE OF THE ATMOSPHERICAL ELECTRICAL POTENTIAL ON PLANTS.

BY N. F. MONAHAN.

While electrical currents have such an important influence upon the growth and development of plants, as shown in the preceding pages, so also does the electrical potential of the atmosphere have an appreciable influence upon plant life. The atmosphere is always charged to a higher or lower electrical potential, either positive or negative. This has been clearly shown by experiments conducted by the Weather Bureau, United States Department of Agriculture, by Alexander McAdie of the Blue Hill Observatory, and by A. C. Monahan of this station. The conditions governing the amount of electrical potential of the air are not clearly understood, but Monahan found, in a series of experiments extending over nearly a year's time, that the air was charged positively about 90 per cent. of the whole time at a height of 30 feet from the ground. It is enough for us to know, however, that the air is always charged to a higher or lower potential. It is the purpose of this paper to show in a brief way some of the results of preliminary experiments on the effects of atmospherical electrical potential on germination, and the growth and development of plants. Fuller accounts will be published later.

Methods of Experiments and Apparatus used.

In all our experiments we have kept careful records of the exact electrical potential. These records were made by the use of a quadrant electrometer, designed by Sir William Thomson for observations in atmospherical electricity, and built by Eliot Bros. of London. In brief, the instrument consists of a delicate quadrant galvanometer and a self-registering apparatus. A full description of this instrument may be found in the twenty-eighth annual report of the Massachusetts Agricultural College, for 1891.

We used a large glass case, with a wooden frame, 4 feet 3 inches long, 2 feet 9 inches wide, and 2 feet 11 inches high, with a detachable door in the middle of one side, from which every part of the case was accessible. The door was made to fit tightly by a band of rubber around the edge, and was securely held in place by levers. When closed, the case was practically air tight, and was insulated from the stand by glass and rubber insulation. In one corner of the case a small water-dripping apparatus was placed. This apparatus consisted of a light eight-quart copper tank, with a projecting pipe which ended in a fine orifice; the water passing through the pipe immediately broke into drops, and was caught in a glass dish below. An insulated wire connected the case with the electrometer near by. A short time after the dripping started the tank was found to be electrified, presumably to the same potential as the air at the point of the projecting tube. The potential was imparted through the conductors to the electrometer, and a deflection of the needle ensued.

In the case was also placed a self-recording hygrometer (Richard Bros., Paris) and a self-registering thermometer. The case was charged in some instances through a wire at one end leading from a Holtz influence machine. Immediately after charging, the wire was withdrawn from the case, and the hole through which it was inserted was tightly plugged. At other times the case was charged from a Leyden jar through the same wire. This seemed necessary in order to get the required small potential. The air in the case would hold a part of its charge for about three hours; at the end of that time we could find no trace of any electrical potential. The growth of the plants was measured in some instances by a modified Pfeffer-Baranetzky self-registering auxometer, and in other cases by the use of a horizontal microscope with a micrometer scale attachment.

EFFECT ON GERMINATING SEEDS.

Two lots of one hundred seeds of each kind were taken. These seeds were placed in porous clay dishes and soaked for six hours. The first lot was placed in Case 1, and subjected to an electrical charge every eight hours, induced into the air of the case from the Holtz machine. The second lot was placed in Case 2, — a small glass case, where no electrical charge was allowed. In all instances the clay dishes were set in basins of water, so that the seeds were moist at all times. The conditions of the temperature and moisture were practically the same, the former varying from 18° to 20° C., the latter from 76 to 85 per cent. Both cases were closed, and under similar conditions.

TABLE 1. — *Showing Effect of a Positive Charge upon Germinating Seeds.*

[N, normal; C, charged.]

KIND OF SEED.		TOTAL NUMBER OF SEEDS GERMINATED IN —				
		24 Hours.	**48** Hours.	**72** Hours.	**96** Hours.	**120** Hours.
White clover, ...	N,	–	–	56	67	76
	C,	2	59	72	79	80
Onion, ...	N,	5	23	30	34	40
	C,	3	41	47	51	51
Onion, ...	N,	–	3	13	18	44
	C,	–	5	17	28	37
Lettuce, ...	N,	–	34	48	56	77
	C,	–	55	82	85	85
Red clover, ...	N,	–	7	18	35	66
	C,	–	74	88	92	92
Total per cent. acceleration in charged seeds,		–	55.4	23.1	17.11	–

TABLE 2. — *Showing Effect of a Positive Charge upon Seeds that have lost Vitality.*

KIND OF SEED.		TOTAL NUMBER OF SEEDS GERMINATED IN —				
		24 Hours.	**48** Hours.	**72** Hours.	**96** Hours.	**120** Hours.
Musk melon, ...	N,	–	–	–	–	–
	C,	–	1	1	1	1
Onion (Red Globe), ...	N,	–	1	–	2	2
	C,	1	2	2	3	3
Onion (Belden), ...	N,	9	25	33	33	33
	C,	7	18	20	20	20

Table 2 shows that atmospheric electricity does not increase the total number of seeds germinated over the total germination of those not charged, and that it does not bring to life seeds that have lost their vitality. Seed of a very low per cent. of germination were used.

The results obtained from these experiments confirmed the work done in 1896 at this station by Asa S. Kinney, on "Electro-Germination."[1] Kinney found that: first, electricity exerts an appreciable influence upon the germination of seeds; second, the application of certain strengths of current to seeds for a short period of time accelerates the processes of germination; third, the application of electrical currents to seeds does not increase the total percentage of germination. This latter result shows a direct opposition to the results obtained by Paulin. Paulin claimed that the application of electrical currents awakened to life seeds which had apparently lost vitality, and gave an increased percentage of germination in all seeds thus stimulated.

Effects on Plant Growth.

In some of our experiments three young tomato plants were placed in the large glass case and allowed to stand for eight hours. This was done in order that the plants might become accustomed to the changed conditions and to their new environment before being experimented upon. In these experiments the air in the case was charged every eight hours (at 7 A.M., 3 P.M. and 11 P.M.) to a potential of from 100 to 2,000 volts, as recorded by the electrometer and the growth of the plants recorded by the Pfeffer-Baranetzky self-registering apparatus. This method of measuring the growth proved unsatisfactory and was soon abandoned, and the following method, which proved more satisfactory, was tried. One plant at a time was placed in the case and allowed to stand for a few hours, as above; the plant was then set up near the glass on one side of the case, and the growth measured by means of a horizontal microscope with a micrometer scale attachment, the microscope being placed on the outside of the case and focused upon the apex of the plant, measurements being taken every fifteen minutes.

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[1] "Electro-Germination." Bulletin No. 43, Hatch Experiment Station.

The following figure shows the results of one experiment. A small tomato plant about four inches high was placed in the case, and treated as before described. Measurements of growth were recorded every fifteen minutes, from 10.15 A.M. to 5 P.M. From 10.15 until 11.30 there was no perceptible growth. At 10.30 the air in which the plant was growing was charged to a potential of 70 volts. Half an hour later, at 12 o'clock, the plant had grown two spaces on the micrometer scale; and at 12.15 had grown two more spaces; and so on until 2.15, when no growth was recorded. At 2.45 the air in the case was recharged to 80 volts, and a greatly increased growth resulted, the maximum acceleration taking place at 1.15 and 4 o'clock respectively, as a result of the two stimuli.

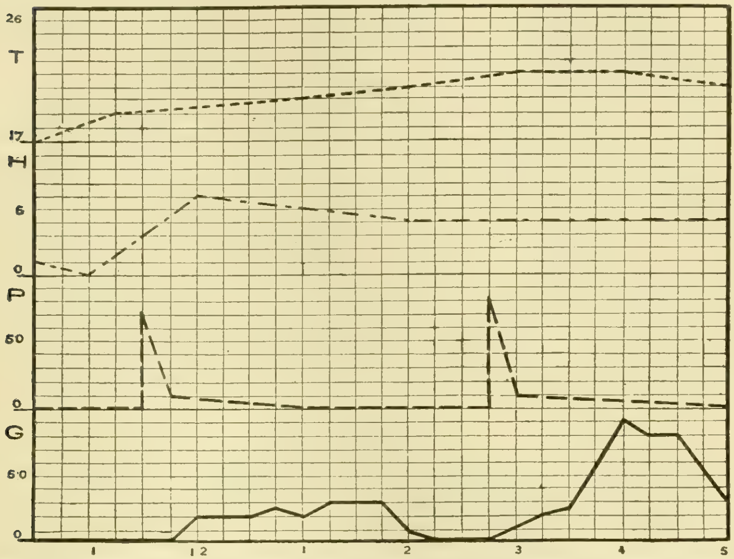

FIG. 1. — Growth curve of tomato plant. The horizontal divisions represent periods of fifteen minutes in time; the vertical divisions represent degrees of temperature, also humidity, electrical potential and increments of growth. T, temperature; H, humidity; P, electrical potential; G, growth.

This is but one of many similar figures showing the results of our experiments, tomato plants, corn cotyledons and bread moulds (*mucor* and *Phycomyces nitens*) being used. In all of these experiments the latent period varied from fifteen to thirty minutes.

In several of the experiments where the conditions of temperature and moisture were practically the same, and a large potential was employed, a serious retardation was shown, and in some instances death ensued ; in other cases, where a very small potential was employed, no appreciable acceleration was shown.

From these facts we are led to believe that there is a maximum, optimum and minimum voltage ; and, from the fact that different potentials were required to stimulate the growth of plants of different species, — and, in fact, of plants of the same variety and apparently of the same size, — it is evident that the maximum, optimum and minimum potentials vary with different varieties and species of plants, and also with plants of the same variety, depending upon the size, structural differentiation, development, etc., of the individual plant.

Summary.

1. Atmospheric electricity exerts an appreciable influence upon the germination of seeds.

(*a*) It accelerates the processes of germination. (In the experiments tried, those seeds charged with electricity show an acceleration in germination of 55.4 per cent. in forty-eight hours, 23.1 per cent. in seventy-two hours, and 17.11 per cent. in ninety-six hours.)

(*b*) It does not increase, to an appreciable extent, the total germination of charged seeds over the normal.

(*c*) It does not awaken to life seeds which have lost vitality.

2. Atmospheric electricity has an appreciable influence upon the growth of plants.

(*a*) From the results of these experiments we are led to believe that there is a maximum, optimum and minimum potential, but these have not yet been accurately determined.

(*b*) That the maximum, optimum and minimum voltages vary not only with the different varieties or species of plants, but with different individuals of the same varieties, and species depending largely upon the size, structural differentiation and degree of development of the plant.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.

Chemical Assistants: E. B. HOLLAND, P. H. SMITH, W. E. TOTTINGHAM.
Inspector of Feeds, Babcock Machines and Dairy Tester: ALBERT PARSONS.
In Charge of Feeding Experiments: JOSEPH G. COOK.
Stenographer: MABEL SMITH.

Part I. — Outline of Year's Work.

- A. Correspondence.
- B. Extent of chemical work.
- C. Character of chemical work.
  - (*a*) Water.
  - (*b*) Dairy products and feed stuffs.
  - (*c*) Chemical investigation.
- D. Cattle feed inspection.
- E. Execution of the dairy law.
- F. Testing dairy herds.
- G. Work in progress and completed.
- H. Addition to staff.

Part II. — Dairy and Feeding Experiments.

- A. Effect of feed on the composition of milk and butter fat, and on the consistency or body of butter.
- B. Digestion experiments with sheep.
- C. Raising dairy calves without milk.

PART I. — OUTLINE OF YEAR'S WORK.

J. B. LINDSEY.

A. CORRESPONDENCE.

The correspondence of this department has considerably increased over previous years, due to the execution of the new feed law. The general character of the information desired has been much the same as heretofore. The total number of letters sent out during the year has been about 3,000.

B. EXTENT OF CHEMICAL WORK.

The work in the laboratory has been of the same general character as formerly. The number of determinations of butter fat in cream has considerably increased.

There have been sent in for examination 132 samples of water, 229 of milk, 1,766 of cream, 8 of pure and process butter and 170 of feed stuffs. In connection with experiments by this and other divisions of the station, there have been analyzed, in whole or in part, 235 samples of milk and 585 of fodders and feed stuffs. There have also been collected and tested under the provision of the feed law 772 samples of concentrated feed stuffs. This makes a total of 3,897 substances analyzed during the year, as against 3,240 last year and 3,622 in the previous year. Work on moisture, fiber and fat, and on the availability of organic nitrogen, not included in the above, has been done for the Association of Official Agricultural Chemists, and required considerable time for its proper execution. In addition, 17 candidates have been examined and given certificates to operate Babcock machines, and 2,240 pieces of glassware have been tested for accuracy, of which 57 pieces, or 2.54 per cent., were condemned.

C. CHARACTER OF CHEMICAL WORK.

(a) *Water.*

In accordance with instructions from the experiment station committee, a charge of three dollars has been made for each sample of water examined by this department during the past year. The reasons for this charge were explained in a small circular sent to each applicant, a copy of which was printed in the last report, page 50. Most applicants have cheerfully paid the fee, while others have refused to send the sample for examination because of the charge. The number of samples examined has been 132, considerably less than formerly; but it is believed that the charge has resulted in holding in check those who have heretofore sent from 4 to 20 samples annually, as well as those who have sent largely out of curiosity, because an analysis could be had free of cost.

Instructions for securing an analysis of water: —

Those wishing to secure a sanitary analysis of water must first apply, whereupon a glass bottle securely encased, accompanied by full instructions for collecting and shipping the sample, will be forwarded by express. The return expressage must in all cases be prepaid. Because of the smallness of the sum involved, no account will be opened. Remittance by check, P. O. money order, or money at the owner's risk, must be strictly in advance.

Application may be made and money sent to

Dr. J. B. LINDSEY,
Hatch Experiment Station.

(b) *Dairy Products and Feed Stuffs.*

The number of samples of milk and cream sent largely for the purpose of determining their butter fat content is increasing from year to year. The increase in the number of cream samples comes largely from creameries, while the milk comes from farmers desirous of ascertaining the quality produced by the several animals in the herd. This latter is a very satisfactory sign, and should meet with every encouragement. Printed circulars are sent in answer to inquiries, giving concise information concerning the quality of the milk produced by different breeds, as well as full instructions relative to the best methods to be employed in determining the butter-producing capacity of dairy herds. Comparatively little analysis has been done for the Dairy Bureau, because of the pressure of other lines of work.

The number of feed stuffs sent for examination was about the same as usual. They are examined at once, and the results forwarded promptly, with such suggestions as circumstances may advise. Numerous samples are received from dealers, who avail themselves of the station facilities to make sure the materials they are offering are as claimed.

(*c*) *Chemical Investigation.*

So far as time and facilities permit, this department continues its work of investigating the various problems connected with the chemistry of dairying and animal nutrition. A good deal of attention has been given to the composition and digestibility of feed stuffs, as well as to the effect of feeds and feed combinations upon the quantity and quality of milk. A study of methods of analyses has been referred to elsewhere.

D. CATTLE FEED INSPECTION.

In October and November, 1902, quite a thorough canvass of the State was made, some 320 samples of feeds collected, examined, and the results published in Bulletin No. 85. Because of the limited funds available, a few samples only — principally of cotton-seed meal — were collected in the late winter. The Legislature at its session of 1903 passed a new feed law (chapter 122, Acts of 1903); the full text of this law may be found in Bulletin No. 93, recently issued by this department. A brief synopsis of the law is as follows: —

Section 1 defines statements to be attached to all packages of feed stuffs.

Section 2 specifies feed stuffs included in the law.

Section 3 defines feed stuffs exempt from the law.

Section 4 states the penalty for violations of previous sections.

Section 5 mentions duties of director or deputy with reference to collecting and analyzing samples, and states penalty for interference.

Section 6 declares against the adulteration of whole or ground grain or standard by-products, and fixes penalty.

Section 7 requires the director to prosecute violations of the act.

Sections 8, 9 and 10 define the term importer, state the sum to be allowed for carrying out the provisions of the act, etc.

It is believed that the law will prove of great benefit to farmers, and they are to be congratulated upon its enactment. Similar laws are now in force in all of the other New England States, as well as in New York, New Jersey, Pennsylvania, Maryland, North Carolina and Wisconsin.

The new feed law went into effect July 1. Mr. Albert Parsons was appointed inspector, and has made a thorough canvass of the State, collecting some 700 samples. It is proposed to keep the inspector at work in different sections of the State a considerable portion of the year; in this way the station can be kept thoroughly informed concerning the character of the feeds offered. As would naturally be supposed, many feeds were found unmarked and without a guaranty, and it will require some time and considerable patience to bring about a complete conformity to the law. On the whole, it may be said that dealers appear ready and willing to conform to its requirements, and are constantly addressing letters of inquiry to the station concerning the character and value of the manifold feeds offered by manufacturers and jobbers. The station stands ready to co-operate with consumer, local dealer, jobber and manufacturer, to the end that all may be benefited.

The details of this inspection will be found in Bulletin No. 93.

E. Execution of the Dairy Law.

This department issued a special bulletin on the subject in July of the present year, entitled "The Dairy Law and its Results." The bulletin gave the text of the law, an account of the inspection of glassware, of the inspection of Babcock machines, very full information concerning the method of manipulating the Babcock milk test, together with as complete a list as possible of the creameries and milk depots in Massachusetts. This bulletin was sent in lots of from 10 to 100 to all milk depots and creameries in the State.

Inspection of Glassware. — All glassware found to be correct is marked "Mass. Ex. St.," by means of sand blast. During 1902 there was examined 2,344 pieces, of which 56 pieces, or 2.39 per cent., were found incorrect. There have been examined the present year (1903) 2,240 pieces, of which 57 pieces, or 2.54 per cent., were not correctly graduated. Manufacturers are now very careful concerning the accuracy of the glassware put out by them.

Examination of Candidates. — Mr. E. B. Holland has continued as heretofore to have charge of this work. During 1901, 45 candidates were examined; in 1902, 13 candidates; and the present year, 17 have been given certificates of competency. It is believed that practically all parties now operating Babcock machines under the law have a good understanding of the principles of manipulation, and are capable of doing accurate work.

Inspection of Babcock Machines. — The inspection of machines the present year has been in charge of Mr. Albert Parsons, who makes the following report: —

The third annual inspection of Babcock machines was made in November and December, 1903. Fifty-two establishments were either visited or heard from, 37 being creameries and 15 milk depots. Twenty-four, or half the number, were co-operative, 18 were proprietary, and 10 were managed by stock companies. Forty machines were inspected. Of these, 1 was condemned and 6 needed slight repairs. A few overheated the tests, and a few required additional steam to warm them. All but two of the machines were run by steam power, one was run by hand and one by electricity. About three-fourths of the machines have frames of cast iron, while the other fourth is equally divided between galvanized iron and copper. Of the cast-iron machines, 22 are "Facile," and 9 are "Agos." As a rule, the glassware was found in good condition, although in some cases it was very dirty, in a few cases it was not tested, and a few pieces bore the mark of another State.

F. Testing Dairy Herds.

During the year this department has tested cows at the request of the Jersey, Guernsey and Holstein cattle clubs. Fifteen seven-day tests and 6 yearly tests have been completed and 38 yearly tests are in progress. The tests are made under the rule and regulations of the several clubs. It requires at the present time the services of a man during two weeks in each month, and in addition involves considerable clerical work.

G. Work in Progress and completed.

At the present time, experiments are in progress to note the value of specially prepared dried blood and digester tankage for milk production. It is believed that material of this kind will be used considerably in the near future as a source of protein for farm animals. Other experiments now in operation are: (*a*) to test the efficacy of a well-known condimental or medicated food, for which extravagant claims are made; (*b*) digestion experiments on a variety of coarse and concentrated feeds.

Experiments were also continued with summer-forage crops; but, owing to the very unusual summer conditions, definite results were not obtained, and they will be continued. An experiment is about to be undertaken to see if it is economically possible for the average dairy farmer to get along without the use of wheat bran, using silage as a diluter for the more concentrated by-products. Experiments have been completed with distillers' by-products, — malt sprouts, dried brewers' and distillers' grains, — and the results will soon be published in bulletin form. These experiments emphasize the nutritive and economical value of these several feeds as sources of digestible protein for milk production.

H. Addition to Staff.

Messrs. W. E. Tottingham, Albert Parsons and Joseph G. Cook have been recently added to the staff of this department. Mr. Tottingham serves as assistant chemist, taking the place made vacant by T. M. Carpenter, who secured a more lucrative and responsible position at the Pennsylvania experiment station. Mr. Parsons fills, in a sense, a new position, rendered necessary by the increasing work placed upon the department. He is acting as inspector of feed stuffs under the new feed law, as inspector of Babcock machines under the dairy law, and as dairy herd tester. Mr. Cook has charge of the experiments in animal nutrition at the feeding barn. These several young men have taken hold of the work earnestly and have proved themselves most efficient and satisfactory.

PART II. — DAIRY AND FEEDING EXPERIMENTS.

A. EFFECT OF FEED ON THE COMPOSITION OF MILK AND BUTTER FAT, AND ON THE CONSISTENCY OR BODY OF BUTTER.

J. B. LINDSEY.[1]

EXPERIMENT VIII.

A general outline of experiments of a similar character will be found in the thirteenth and fourteenth reports of this station.

Object of the Experiment. — During the autumn and winter of 1901–02 a series of experiments was undertaken, for the purpose of noting, respectively, the effect of corn gluten meal with a minimum percentage of oil, of gluten meal with the addition of corn oil, and of corn meal, upon the relative proportions of the several ingredients in milk and butter fat, and upon the body of butter.

Plan of the Experiment. — Ten cows were divided into two lots of five each. Seven of the cows had calved in the late summer and early autumn, one in the preceding April, and two had been in milk about a year. The average milk product of each cow at the beginning of the trial was about 21 pounds daily. During the first period, both herds received the so-called standard grain mixture; during the three subsequent periods, Herd I. continued to receive the standard grain ration as in the first period; and in case of Herd II., a portion of the standard ration was replaced by gluten meal, by gluten meal and corn oil, and by corn meal, respectively.

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[1] With E. B. Holland and P. H. Smith.

TABLE I. — *Duration of Experiment.*

PERIODS.	Character of Rations.	Dates.	Length of Periods (Weeks).
1, . .	Herd I., standard grain ration, Herd II., standard grain ration,	Oct. 20 through Nov. 9, .	3
2, . .	Herd I., standard grain ration, Herd II., gluten meal ration, .	Nov. 23 through Dec. 27,	5
3, . .	Herd I., standard grain ration, Herd II., gluten meal + corn oil,	Jan. 2 through Feb. 28, .	7
4, . .	Herd I., standard grain ration, Herd II., corn meal ration, .	Mar. 16 through Apr. 19,	5

Feeding and Care of the Animals. — The animals were fed twice daily. The corn oil was weighed out each day and carefully mixed with the grain ration, and was eaten without any trouble. Water was supplied constantly, by the aid of the Buckley self-watering device. Each cow was kept in a well-bedded, roomy stall, and was turned into a protected yard during the warmest part of each day when the weather was not actually stormy or severely cold. The feeding barn was heated to a temperature of 50–55° F. during the cold weather, kept clean and well ventilated. The animals were thoroughly cleaned daily, and before milking the udders were brushed and then wiped with a wet cloth. The milkers wore white duck suits.

Disturbances during the Experiment. — Just before the beginning of the second period, cow Folly of Herd II. was taken severely ill, and had to be permanently removed. It was thought best to continue the experiment as planned, using four cows in Herd II., rather than to begin again. In the third period, Red II. of Herd II. suffered an attack of indigestion. For this reason, samples of milk were not taken for two weeks, and butter making was omitted for one week. These interferences will be referred to again under "Composition of the milk," "Composition of the butter fat," etc.

TABLE II. — *Average Daily Rations for Each Cow (Pounds).*

First period: both herds, standard ration.

HERDS.	Standard Grain Ration.	Chicago Gluten Meal.	Corn Oil.	Corn Meal Mixture.	First Cut Hay.	Rowen.
Herd I., . . .	8.6	–	–	–	12.4	10.1
Herd II., . . .	8.4	–	–	–	12.8	10.0
Second period: Herd I., standard grain ration; Herd II., gluten meal ration.						
Herd I., . . .	7.9	–	–	–	11.1	10.0
Herd II., . . .	5.3	2.7	–	–	11.5	10.0
Third period: Herd I., standard grain ration; Herd II., gluten meal and corn oil ration.						
Herd I., . . .	7.9	–	–	–	10.9	9.9
Herd II., . . .	4.7	2.1	.6	–	9.2	9.8
Fourth period: Herd I., standard grain ration; Herd II., corn meal mixture.						
Herd I., . . .	7.2	–	–	–	10.9	10.0
Herd II., . . .	–	–	–	7	10.5	10.0

Character of the Rations and Feeds. — The standard grain mixture consisted of 3 pounds of wheat bran, 5 pounds of ground oats and ½ pound each of cotton-seed and gluten meals. It is not to be inferred that this so-called standard ration is superior to all other rations, but simply that it was thought to be a safe and desirable ration, and likely to produce normal milk and butter.

The corn meal mixture was similar to the standard grain ration, excepting that the 5 pounds of ground oats were replaced by an equal amount of corn meal. It is to be understood that the figures given in Table II. represent the average feed consumed daily by each cow in each herd. For example, theoretically each herd in the first period was to consume an equal amount of feed per cow, namely, 8 pounds of grain, 10 pounds of rowen and 12 pounds of first cut hay; but, because of the individual requirements of the several cows, there was a slight difference in case of the average consumed by the two herds.

The spring wheat bran and cotton-seed meal were of good average quality. The oats were of standard quality, purchased whole and ground by the local miller. The Chicago gluten meal contained 40 per cent. of protein and 3.91 per cent. of fat in dry matter, thus furnishing a high percentage of corn gluten and a minimum percentage of corn oil. The corn was grown upon the station grounds, likewise the hay and rowen. The first cut hay was largely timothy, with a small admixture of red-top and clover. It contained 8.24 per cent. of protein in dry matter, and the rowen 14.20 per cent. The corn oil, procured of the Glucose Sugar Refining Company of Chicago, had a golden-yellow color, was clear, and had a marked odor of Indian corn. It was regarded as a very satisfactory sample.

TABLE III. — *Average Dry Matter and Digestible Nutrients in Ration of Each Cow.*

First period: both herds, standard grain ration.

HERDS.	Total Dry Matter.	DIGESTIBLE ORGANIC NUTRIENTS.			Nutritive Ratio.
		Protein.	Carbohydrates.	Fat.	
Herd I., ...	27.37	2.55	13.33	.68	1:5.8
Herd II., ...	27.12	2.52	13.22	.67	1:5.8

Second period: Herd I., standard grain ration; Herd II., gluten meal ration.

HERDS.	Total Dry Matter.	Protein.	Carbohydrates.	Fat.	Nutritive Ratio.
Herd I., ...	25.39	2.39	14.42	.63	1:6.6
Herd II., ...	25.87	2.92	14.04	.59	1:5.3

Third period: Herd I., standard grain ration; Herd II., gluten meal and corn oil ration.

HERDS.	Total Dry Matter.	Protein.	Carbohydrates.	Fat.	Nutritive Ratio.
Herd I., ...	25.34	2.39	12.32	.63	1:5.7
Herd II., ...	23.41	2.55	11.13	1.14	1:5.4

Fourth period: Herd I., standard grain ration; Herd II., corn meal ration.

HERDS.	Total Dry Matter.	Protein.	Carbohydrates.	Fat.	Nutritive Ratio.
Herd I., ...	24.97	2.30	12.17	.61	1:[illegible].9
Herd II., ...	24.55	2.10	13.12	.59	1:6.9

TABLE IV. — *Average Quantity of Milk produced by Each Cow.* (*Pounds.*)

FIRST PERIOD.		SECOND PERIOD.		THIRD PERIOD.		FOURTH PERIOD.	
Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
448.56	458.41	635.75	684.22	924.34	998.27	620.59	636.62

During the first period both herds produced essentially the same average quantity of milk per cow; during the second and third periods, presumably because of the increased supply of protein in the daily ration, Herd II. showed a slightly larger average yield.

Purity of the Milk. — A number of samples of the mixed milk were taken immediately after milking, placed in sterilized glass-stoppered bottles, and kept cold until examined for bacterial content. The number of bacteria varied from 200 to 3,600 to the cubic centimeter, showing the milk to be especially clean. Objectionable odor or flavor could not be detected.

Sampling the Milk. — Composite samples of the mixed milk from each herd were taken for five days in each week, and tested for total solids, fat and nitrogen. The solids were determined by drying in sand, the fat by extracting the dry material with ether, and the nitrogen by the Kjeldahl method. In securing a sample, the milk from each herd was carefully mixed, and a small dipperfull taken immediately.

TABLE V. — *Composition of Milk* (*Per Cent.*).

First period: both herds, standard ration.

SAMPLES.	TOTAL SOLIDS.		FAT.		SOLIDS NOT FAT.		NITROGEN.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
Oct. 26–30, . .	14.25	14.10	5.13	5.12	9.12	8.98	.573	.565
Nov. 1–4, . .	14.63	14.43	5.33	5.32	9.30	9.11	.584	.580
Nov. 4–9, . .	14.58	14.50	5.43	5.38	9.15	9.12	.576	.569
Average, . .	14.49	14.34	5.30	5.27	9.19	9.07	.578	.571

TABLE V. — *Composition of Milk* — Concluded.

Second period: Herd I., standard ration; Herd II., Chicago gluten meal ration.

SAMPLES.	TOTAL SOLIDS.		FAT.		SOLIDS NOT FAT.		NITROGEN.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
Dec. 11-16,	14.97	14.67	5.50	5.28	9.47	9.39	.594	.600
Dec. 17-22,	15.05	14.80	5.59	5.29	9.46	9.51	.599	.616
Dec. 22-27,	14.75	14.50	5.49	5.17	9.26	9.33	.600	.613
Average,	14.92	14.66	5.53	5.25	9.39	9.41	.598	.610

Third period: Herd I., standard ration; Herd II., Chicago gluten meal and corn oil ration.

SAMPLES.	TOTAL SOLIDS.		FAT.		SOLIDS NOT FAT.		NITROGEN.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
Dec. 28-Jan. 3,[1]	14.79	14.64	5.40	5.43	9.39	9.21	–	–
Jan. 5-Jan. 10,[1]	14.61	14.49	5.35	5.37	9.26	9.12	–	–
Jan. 12-17,	14.69	14.16	5.29	5.10	9.40	9.16	.586	.567
Jan. 19-24,	14.76	14.23	5.31	5.12	9.45	9.11	.604	.580
Jan. 16-31,	14.74	14.11	5.27	4.97	9.47	9.14	.597	.586
Feb. 2-7,	14.66	14.07	5.29	5.02	9.37	9.05	.597	.579
Feb. 9-14,	14.79	14.13	5.31	4.99	9.48	9.14	.599	.577
Feb. 23-28,	14.75	14.08	5.38	4.97	9.37	9.11	.587	.566
Average,	14.73	14.13	5.31	5.03	9.42	9.12	.595	.576

Fourth period: Herd I., standard ration; Herd II., corn meal ration.

SAMPLES.	TOTAL SOLIDS.		FAT.		SOLIDS NOT FAT.		NITROGEN.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
Mar. 3-8,[1]	14.68	13.69	5.25	4.43	9.43	9.26	.589	.576
Mar. 9-14,[1]	14.59	14.29	5.34	5.18	9.25	9.11	.590	.576
Mar. 16-21,	14.93	14.27	5.42	5.11	9.51	9.16	.606	.586
Mar. 23-28,	14.70	14.28	5.27	4.99	9.43	9.29	.597	.586
Mar. 31-Apr. 4,	14.82	14.52	5.19	5.10	9.63	9.42	.610	.597
Apr. 6-11,	15.00	14.37	5.36	5.12	9.64	9.25	.620	.603
Apr. 13-18,	14.84	14.29	5.13	5.03	9.71	9.26	.619	.608
Average,	14.86	14.35	5.27	5.07	9.58	9.28	.610	.596

[1] Preliminary.

TABLE VI. — *Relation of Fat to Solids not Fat.*

FIRST PERIOD.		SECOND PERIOD.		THIRD PERIOD.		FOURTH PERIOD.	
Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
1: 1.73	1: 1.72	1: 1.70	1: 1.79	1: 1.77	1: 1.81	1: 1.82	1: 1.83

It is desired at this point to again call attention to the important fact that cow Folly in Herd I. became suddenly ill between the first and second periods, and had to be permanently removed from the experiment. It was thought best, however, to continue the experiment as planned, rather than attempt to start again.

It will be seen, in observing the above tables of analyses, that in the first period, with five cows in each herd and both herds receiving the same ration, the composition of the milk was quite similar. This was, of course, due to the fact that the two herds had been evenly matched. The milk yield of both herds in this period was also essentially the same, namely, 2,243 pounds for Herd I. and 2,292 pounds for Herd II.

In the second period, because of the loss of Folly, it was not possible to make a comparison of the composition of the milk produced by the two herds; hence it was sampled only during the last three weeks, in order to secure a basis of comparison for the two following periods. In this period the relation of fat to solids not fat was 1 : 1.70 and 1 : 1.79 for herds I. and II. respectively.

In the third or corn oil period the composition of the milk produced by both herds is given for the two preliminary weeks as well as for the period proper, although the former is not included in the average. The results show that the milk produced by Herd I. remained quite constant in composition during the entire period. A slight decrease only in the fat percentage is noted, the relation of the fat to solids not fat being as 1 : 1.77. In case of Herd II. the fat percentage suddenly increased from an average of 5.25 to 5.40 during the preliminary period of two weeks, when the corn oil was being added to the ration. The relation of fat to solids not fat during the preliminary period was as 1 : 1.72. The effect of the corn oil appeared to have been lost after two weeks, for during the first week of the period proper the percentage of fat was 5.10, and it declined slightly during the period, with an average of 5.03 and a relation of fat to solids not fat of 1 : 1.81. While the total solids did not change during the preliminary period, they showed a decrease at the close of the period proper of .53 per cent. It is to be noted that the nitrogen during this period was .034 per cent. lower than in the previous period. A similar decrease was noticed when linseed oil was fed.[1]

The percentage of solid matter in both herds suffered a slight decline during the third period, possibly due to winter weather conditions; but it was greater in case of Herd II., due largely to the decrease of the solids not fat.

In the fourth or corn meal period the milk of Herd I. increased a little in total solids, perhaps due to advanced lactation or to warmer weather. In case of Herd II., the sudden removal of the corn oil caused a temporary decrease of .54 per cent. of fat and a slight increase in the nitrogen. The so-called fat equilibrium, however, was gradually restored; for in the second week of the preliminary period it was equal to that yielded during the last week of the former period, and the percentage continued quite regular during the entire period. The percentage of nitrogen gradually increased for several weeks, and during the last week of the period it was equal to the average percentage found during the second period. Similar conditions were observed in former experiments.[2]

Attention is called to the evenness in the composition of the milk produced by Herd I., which had the same feed for a period of six months, the only change worthy of notice being the gradual increase of the solids not fat from 9.19 to 9.58 per cent.

TABLE VII. — *Composition of the Butter Fat.*[3]

First period: both herds, standard ration.

NUMBER SAMPLES, EACH HERD.	SAPONIFICATION EQUIVALENT.		REICHERT-MEISSL NUMBER.		MELTING POINT (DEGREES C.).		IODINE NUMBER.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
2 samples, . . .	231.5	230.6	30.03	29.52	33.78	33.43	29.07	30.29
2 samples, . . .	231.1	231.0	29.74	29.56	34.43	33.70	29.31	29.75
2 samples, . . .	231.1	231.9	29.48	30.25	34.13	33.48	27.76	29.06
Average, . .	231.2	231.2	29.75	29.78	34.11	33.54	28.71	29.70

[1] Thirteenth report of this station, pp. 107-109.

[2] *Loc. Cit.*

[3] Methods of the Association of Official Agricultural Chemists.

TABLE VII. — *Composition of the Butter Fat* — Concluded.

Second period: Herd I., standard ration; Herd II., Chicago gluten meal ration.

Number Samples, Each Herd.	Saponification Equivalent.		Reichert-Meissl Number.		Melting Point (Degrees C.).		Iodine Number.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
2 samples, . . .	231.6	231.9	29.20	29.17	34.53	33.13	26.66	28.63
2 samples, . . .	232.2	232.3	29.52	29.91	34.40	33.43	27.42	29.50
2 samples, . . .	231.1	232.3	29.03	28.66	34.55	32.93	26.91	28.99
2 samples, . . .	232.7	233.7	29.39	28.48	34.58	33.08	26.95	29.59
Average, . .	231.9	232.6	29.29	29.06	34.52	33.17	26.96	29.18

Third period: Herd I., standard ration; Herd II., Chicago gluten meal and corn oil ration.

Number Samples, Each Herd.	Saponification Equivalent.		Reichert-Meissl Number.		Melting Point (Degrees C.).		Iodine Number.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
2 samples, . . .	230.6	226.0	28.80	28.30	33.83	33.33	26.89	36.68
2 samples, . . .	230.2	224.7	30.20	27.80	33.90	32.93	27.47	37.35
2 samples, . . .	229.5	221.9	28.75	24.85	33.73	34.28	28.34	38.58
2 samples, . . .	230.5	219.6	28.55	23.20	34.05	34.40	28.18	40.23
2 samples, . . .	230.5	220.9	28.22	23.61	34.33	34.03	27.94	39.00
Average, . .	230.3	222.6	28.90	25.55	33.97	33.79	27.76	38.37

Fourth period: Herd I., standard ration; Herd II., corn meal ration.

Number Samples, Each Herd.	Saponification Equivalent.		Reichert-Meissl Number.		Melting Point (Degrees C.).		Iodine Number.	
	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
2 samples, . . .	229.7	229.0	27.83	26.88	34.18	33.58	28.80	29.51
1 sample, . . .	227.8	229.4	26.64	27.47	34.15	33.70	29.55	29.14
1 sample, . . .	228.4	229.6	26.61	27.43	34.10	33.65	29.68	28.86
2 samples, . . .	229.6	232.4	27.35	27.17	34.28	33.58	29.02	28.84
2 samples, . . .	231.5	231.2	27.14	27.53	34.48	33.98	29.59	28.69
Average, . .	229.4	230.3	27.11	27.30	34.24	33.70	29.33	29.01

In the first period the butter fat produced by both herds showed a very similar composition, trifling variations only being noted in the melting point and iodine number.

In the second or gluten meal period it is difficult to note any change in the composition of the butter fat which may be attributed to the influence of the gluten meal. In a former experiment[1] no striking differences between the butter fat produced by the standard grain ration and a gluten meal ration could be noted. The iodine number of the fat produced by Herd I. showed a noticeable drop during this period, gradually returning during the next two periods to the number indicated in the first period. The reason for this temporary depression is difficult to explain. It is not to be overlooked that the cow Folly was removed during this period, and did not again enter the experiment; it is doubtful, however, if her loss in any way affected the composition of the fat.

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[1] Thirteenth and fourteenth reports of this station, pp. 110, 165.

In the third period Herd II. was still receiving a trifle over 2 pounds of gluten meal daily, so that the ration was essentially the same as in the second period, excepting for the addition of .6 pound of corn oil. It is in this period that a noticeable modification of the butter fat took place with Herd II., while the character of the fat produced by Herd I. remained constant. The difference consisted in the decrease of the saponification equivalent by 10 points, a decrease of the Reichert-Meissl number of $3\frac{1}{2}$ points, and an increase in the iodine number of a trifle over 9 points. The melting point of the fat, on the other hand, showed no marked change. Similar conditions were noted when cotton-seed and linseed oils were fed,[1] excepting that the two latter oils also raised the melting point of the fat.

In the fourth or corn meal period, when the rations of both herds were similar, excepting that corn meal took the place of ground oats with Herd II., the butter fat produced by the latter herd returned to its normal condition, *e.g.*, similar to that produced in the first and second periods, and closely resembling the fat produced by Herd I. during all four periods.

The only noticeable change in the fat of Herd I during the entire experiment,[2] extending from October 20 through April 19, — a period of six months, — consisted in the slight gradual decline in the Reichert-Meissl number, due to advancing lactation. It is interesting to observe the uniformity in the character of butter fat produced by a herd of five cows having the same feed during such a long period of time.

The Opinion of Experts on the Character of the Butter. — Two lots of cream from each herd, raised by the Cooley process, were ripened and made into butter each week. The ripening process generally lasted twenty-four hours, and some commercial starter was employed. The full details of the process are on file, but it is hardly considered necessary in this connection to publish them, other than to state that the most approved methods were followed.

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[1] Thirteenth and fourteenth reports of this station, pp. 110, 165.

[2] Excepting the temporary depression in the iodine number in the second period already referred to.

Pound samples from each lot were sent to Mr. O. Douglass of Boston and Mr. W. A. Gude of New York, who scored them, each being entirely ignorant of the nature of the experiment or of the feeds employed.

TABLE VIII. — *Douglass Butter Scores.*

First period: both herds, standard ration.

FLAVOR.		BODY.		COLOR.		SALT.		STYLE.		TOTAL.	
Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
44.0	43.5	20	20	15	15	10	10	5	5	94.0	93.5
45.0	44.5	20	20	15	15	10	10	5	5	95.0	94.5
45.0	43.0	20	20	15	15	10	10	5	5	95.0	93.0
43.0	43.0	20	20	15	15	10	10	5	5	93.0	93.0
43.0	44.0	20	20	15	15	10	10	5	5	93.0	94.0
Av., 44.0	43.6	20	20	15	15	10	10	5	5	94.0	93.6
Second period: Herd I., standard ration; Herd II., Chicago gluten meal ration.											
43.0	44.0	20	20	15	15	10	10	5	5	93.0	94.0
43.0	43.5	20	20	15	15	10	10	5	5	93.0	93.5
46.0	45.5	20	20	15	15	10	10	5	5	96.0	95.5
45.0	41.0	20	20	15	15	10	10	5	5	95.0	91.0
41.0	43.0	20	20	15	15	10	10	5	5	91.0	93.0
39.0	40.0	20	20	15	15	10	10	5	5	89.0	90.0
Av., 42.8	42.8	20	20	15	15	10	10	5	5	92.8	92.8
Third period: Herd I., standard ration; Herd II., Chicago gluten meal and corn oil ration.											
44.0	46.0	20	19	15	15	10	10	5	5	94.0	95.0
43.5	45.0	20	19	15	15	10	10	5	5	93.5	94.0
44.5	43.5	20	20	15	15	10	10	5	5	94.5	93.5
45.0	46.5	20	20	15	15	10	10	5	5	95.0	96.5
44.0	45.0	20	20	15	15	10	10	5	5	94.0	95.0
45.5	46.5	20	20	15	15	10	10	5	5	95.5	96.5
43.0	45.0	20	20	15	15	10	10	5	5	93.0	95.0
42.0	44.0	20	20	15	15	10	10	5	5	92.0	94.0
44.0	43.5	20	20	15	15	10	10	5	5	94.0	93.5
44.5	45.0	20	20	15	15	10	10	5	5	94.5	95.0
Av., 45.0	45.0	20	20	15	15	10	10	5	5	94.0	94.8
Fourth period: Herd I., standard ration; Herd II., corn meal ration.											
43.0	44.0	20	20	15	15	10	10	5	5	93.0	94.0
42.5	45.0	20	20	15	15	10	10	5	5	92.5	95.0
42.0	43.0	20	20	15	15	10	10	5	5	92.0	93.0
40.0	41.0	20	20	15	15	10	10	5	5	90.0	91.0
45.0	43.0	20	20	15	15	10	10	5	5	95.0	93.0
45.0	40.0	20	20	15	15	10	10	5	5	95.0	90.0
42.0	43.0	20	20	15	15	10	10	5	5	92.0	93.0
43.0	41.0	20	20	15	15	10	10	5	5	93.0	91.0
Av., 42.8	42.8	20	20	15	15	10	10	5	5	92.8	92.5

TABLE IX. — *Gude Butter Scores.*

FLAVOR.		BODY.		COLOR.		SALT.		STYLE.		TOTAL.	
Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
First period: both herds, standard ration.											
35.0	31.0	24.0	23.0	14.5	15.0	10	10	5	5	88.5	84.0
35.0	32.0	25.0	24.0	15.0	15.0	10	10	5	5	90.0	86.0
35.0	30.0	25.0	25.0	15.0	15.0	10	10	5	5	90.0	85.0
30.0	37.0	22.0	22.0	15.0	15.0	10	10	5	5	82.0	89.0
38.0	32.0	24.0	23.0	15.0	15.0	10	10	5	5	92.0	85.0
Av., 35.0	32.0	24.0	23.0	14.9	15.0	10	10	5	5	88.5	85.8
Second period: Herd I., standard ration; Herd II., Chicago gluten meal ration.											
37.0	35.0	24.0	22.0	15.0	15.0	10	10	5	5	91.0	85.0
37.0	36.0	24.0	24.0	15.0	15.0	10	10	5	5	91.0	90.0
32.0	36.0	23.0	24.0	15.0	15.0	10	10	5	5	85.0	90.0
35.0	33.0	25.0	23.0	15.0	15.0	10	10	5	5	90.0	86.0
36.0	36.0	24.0	23.0	15.0	15.0	10	10	5	5	90.0	89.0
28.0	28.0	23.0	23.0	15.0	15.0	10	10	5	5	81.0	81.0
Av., 34.1	34.0	23.8	23.1	15.0	15.0	10	10	5	5	88.0	86.8
Third period: Herd I., standard ration; Herd II., Chicago gluten meal and corn oil ration.											
37.0	40.0	25.0	24.0	15.0	15.0	10	10	5	5	92.0	94.0
37.0	40.0	25.0	24.0	15.0	15.0	10	10	5	5	92.0	94.0
37.0	38.0	24.0	24.0	15.0	15.0	10	10	5	5	91.0	92.0
39.0	40.0	24.0	25.0	15.0	15.0	10	10	5	5	93.0	95.0
42.0	36.0	24.0	24.0	15.0	15.0	10	10	5	5	96.0	90.0
38.0	41.0	24.0	25.0	15.0	15.0	10	10	5	5	92.0	96.0
38.0	40.0	23.0	25.0	15.0	15.0	10	10	5	5	91.0	95.0
38.0	38.0	23.0	23.0	15.0	15.0	10	10	5	5	91.0	91.0
36.0	39.0	25.0	24.0	15.0	15.0	10	10	5	5	91.0	93.0
36.0	39.0	25.0	24.0	15.0	15.0	10	10	5	5	91.0	93.0
Av., 37.8	39.1	24.2	24.2	15.0	15.0	10	10	5	5	92.0	93.3
Fourth period: Herd I., standard ration; Herd II., corn meal ration.											
37.0	37.0	24.0	24.0	15.0	15.0	10	10	5	5	91.0	91.0
37.0	37.0	24.5	24.0	15.0	15.0	10	10	5	5	91.0	91.0
35.0	36.0	25.0	24.5	15.0	15.0	10	10	5	5	90.0	90.5
30.0	33.0	23.0	25.0	15.0	14.0	10	10	5	5	83.0	87.0
41.0	39.0	25.0	25.0	15.0	15.0	10	10	5	5	96.0	94.0
40.0	36.0	25.0	24.0	15.0	15.0	10	10	5	5	95.0	90.0
39.0	39.0	24.0	24.0	15.0	15.0	10	10	5	5	93.0	93.0
38.0	38.0	25.0	24.5	15.0	15.0	10	10	5	5	93.0	92.5
Av., 37.1	36.9	24.4	24.1	15.0	14.9	10	10	5	5	91.5	91.1

As will be seen from the above scores, Mr. Douglass considered the butter produced by both herds during the several periods of good average quality. The flavor he scored a trifle higher in the first and third periods. He found no fault with the body excepting in case of Herd II. in the third period; this butter he repeatedly pronounced as "light bodied, but acceptable in any market."

Mr. Gude appeared to have been much more critical. He often mentioned a "tainted off flavor, as from stale milk," in the butter produced by both herds during the first and second periods. This defect, in our judgment, was due to the starter, with which considerable trouble was experienced, and could in no way be attributed to the feed. The flavor of the butter produced by both herds during the third period was more satisfactory, although it was occasionally referred to as having only a "faint aroma." Mr. Gude several times mentioned the product of Herd II. during this third or corn oil period as having a "fine aroma," and the average score is rather higher than for Herd I. In the fourth period no particular difference in the flavor was observed.

The body of the butter made from Herd I. during all four periods was repeatedly pronounced "short and crumbly;" the body of that produced by Herd II. in the second and fourth periods was also frequently referred to as being crumbly; while that produced by the same herd in the third or corn oil period was sometimes spoken of as satisfactory and sometimes as rather light and rather soft, but suitable for market. It was evident that Mr. Gude liked the flavor and body of the butter produced by the corn oil ration. The same fact was noticed when King gluten meal, containing 14 per cent. of corn oil, was fed.[1]

Personal Observations on the Body of the Butter. — The writer made no attempt to pronounce critical judgment on the flavor of the butter, but endeavored to note particularly the character of the body. No difference could be observed in the body of the butter produced by both herds in the first period. It might be characterized as being hard and firm.

In the second period, pound samples of the butter produced by each herd were allowed to reach a temperature of 57° F. The butter from Herd I. at this temperature appeared noticeably harder and firmer than that produced by Herd II. This conclusion was reached as a result of pushing a glass rod into the mass at different points, and by touching the same with the finger. The same differences were noted at a temperature of 70° F. As the temperature was gradually increased, Herd II. butter showed a tendency to lose form more quickly than Herd I. butter. When the interior of the lumps had reached 83° F., Herd II. butter had lost form, and collapsed into a shapeless, slushy mass; while Herd I. butter still stood up in print form, although showing a tendency to lose its shape. When the room temperature reached 95° F., and the interior temperature of the butter 85° F., Herd I. butter also lost form. It is quite possible that, if this latter butter had been held at 85° F., or even lower, for a considerable time, it would also have fallen into a slushy condition. It will be understood that it is quite difficult to control the exact temperature of a mass of butter. The temperature of the room may be 95° F., while the temperature of the interior of the lump of butter may be 10° lower.

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[1] Thirteenth report of this station, p. 120.

Though the butter produced by Herd II. was softer, lost its form and became slushy more quickly than that produced by Herd I., but little of the fat actually melted until a higher temperature had been reached.

While the differences in the body of the butter produced by the two herds was quite marked, it was probably not sufficient to effect its commercial value, at least during the cooler portion of the year.

Similar observations to the above were made on the two lots of butter produced in the third or corn oil period, the results being even *more pronounced.* At a temperature of 44° F., Herd I. butter was very hard and firm; Herd II. butter, while being hard, had rather a greasy, salvy look, and yielded more easily to the touch. After standing over night at a temperature of 70° F., this difference was very pronounced, the Herd I. product being still firm, while the Herd II. was yielding and soft to the touch. At 82° F., Herd I. butter still retained its print form, while Herd II. butter lost form and was quite slushy. It is believed that the corn gluten and corn oil rations produced rather a softer butter than did the cotton-seed oil ration.[1]

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[1] Fourteenth report of this station, page 167.

But little difference could be noted in the body of the butter produced by both herds during the fourth or corn meal period. At an interior temperature of 60° F. it was not possible to detect any variation. After the butter had stood twenty-four hours in the same room, and showed an interior temperature of 76° F., Herd II. butter appeared to be a trifle softer than Herd I. butter. The difference was certainly not at all pronounced; both lots would be said to possess a hard, firm body.

TABLE X. — *Degrees of Penetration (Millimeters).*

[Each number represents results with one print.]

FIRST PERIOD (32° F.).		SECOND PERIOD (65° F.).		THIRD PERIOD (57° F.).		FOURTH PERIOD (67° F.).	
Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.	Herd I.	Herd II.
4.35	4.05	8.39	11.70	6.45	13.30	12.10	13.17
4.15	4.65	8.60	10.80	6.40	13.15	13.96	14.05
4.35	4.50	9.45	11.90	5.95	12.60	15.50	19.08
4.40	4.55	9.10	12.55	5.95	15.10	16.20	15.75
4.25	4.85	11.00	13.10	7.40	14.65	16.15	16.15
–	–	11.10	16.30	7.05	14.70	15.25	16.50
–	–	10.20	15.50	6.30	14.20	15.79	18.46
–	–	–	–	6.55	13.25	16.40	17.75
–	–	–	–	6.00	13.05	–	–
–	–	–	–	6.95	16.15	–	–
Av., 4.30	4.50	9.69	13.12	6.50	14.02	15.17	16.36

By degrees of penetration is meant the number of millimeters a small glass plunger loaded with mercury will penetrate into butter when dropped for a definite height. Unfortunately, through a misunderstanding, the tests of the butter produced by the two herds in the first period were made a temperature of 33° F., so that the plunger had little opportunity to penetrate. In the other periods the butter was taken from the refrigerator and allowed to stand in the dairy room until it had acquired the room temperature. It will be seen that both in the second and third periods, and particularly in the latter, the butter produced by Herd II. was noticeably softer and more yielding than the product of Herd I. In the fourth period little difference was observed. This method of testing has been criticised, on the ground that different portions of the same lump or print would show widely different degrees of firmness. This claim may be to an extent true. In each case, however, a definite number of tests were made in different parts of each print, and results averaged. The variations were not wide, and the differences in the firmness of the butter are quite striking.

Effect of Feed on the Time of Churning the Cream and on the Quantity of Fat left in the Skim Milk and Buttermilk. — The only noticeable difference in the time of churning was in the third period. One-fifth more time was required to bring the butter from the cream produced by Herd II., receiving the corn oil, than from Herd I., receiving the standard ration.

A number of samples of cream, skim milk and buttermilk were taken in each period and the fat percentages determined, the results being tabulated below: —

TABLE XI. — *Fat in Cream, Skim Milk and Buttermilk.*

FIRST PERIOD.						SECOND PERIOD.					
HERD I.			HERD II.			HERD I.			HERD II.		
Cream.	Skim Milk.	Butter-milk.	Cream.	Skim Milk.	Butter-milk.	Cream.	Skim Milk.	Butter-milk.	Cream.	Skim Milk.	Butter-milk.
15.50	0.11	0.11	16.88	0.07	0.10	18.88	0.23	0.02	16.13	0.34	0.05
17.13	0.08	0.02	16.38	0.13	0.02	17.63	0.24	0.06	16.63	0.34	0.06
18.50	0.18	0.05	16.88	–	0.05	18.50	0.18	0.04	16.88	0.33	0.08
–	–	–	–	–	–	–	–	0.10	–	–	0.12
Av., 17.12	0.12	0.06	16.71	0.10	0.06	18.34	0.23	0.06	16.55	0.34	0.08
THIRD PERIOD.						FOURTH PERIOD.					
17.63	0.20	0.05	18.75	0.15	0.28	–	–	0.41	–	–	0.38
18.18	0.20	0.08	18.50	0.13	0.27	–	0.39	–	–	0.40	–
17.88	0.16	0.09	19.63	0.14	0.24	–	0.43	–	–	0.28	–
18.13	0.20	0.09	17.13	0.23	0.30	–	–	–	–	–	–
18.25	0.24	0.05	18.83	0.20	0.24	–	–	–	–	–	–
18.25	0.20	0.10	16.63	0.23	–	–	–	–	–	–	–
17.63	0.25	0.13	18.75	0.26	0.31	–	–	–	–	–	–
–	–	0.19	–	–	0.40	–	–	–	–	–	–
Av., 17.99	0.21	0.10	18.32	0.19	0.29	–	0.41	0.41	–	0.34	0.38

The results indicate that there was no particular difference in the percentage of fat left in the skim milk or buttermilk produced by the two herds, excepting in case of the buttermilk obtained from the butter produced by Herd II. in the third period, when .20 per cent. more fat was found than in that produced by Herd I. As the period of lactation became advanced, more fat was left in the skim milk produced by both herds. This, however, is a well-established fact with cream raised by the gravity process.

Conclusions. — The fact must not be overlooked that this experiment, on which the following conclusions are based, extended over a period of six months, with periods varying from three to seven weeks in length; the period proper was always preceded by a preliminary period of two weeks.

1. The immediate effect of the addition of .6 pounds of corn oil to the corn gluten meal ration was to increase the fat percentage in the milk .23 of 1 per cent. (5.17 to 5.40); at the end of two weeks the effect of the corn oil had disappeared, and the milk had returned to its normal fat content.

2. The removal of the corn oil from the daily ration caused a sudden drop of .54 per cent. in the fat (4.97 to 4.43), but after the first week the normal fat per cent. was again present.

3. Corn oil appeared to have depressed the nitrogen percentage in the milk by .034 per cent. (.610 to .576); the nitrogen gradually returned to its normal percentage after the feeding of the corn oil had ceased.

4. It is not considered practicable to feed large amounts of oil to cows, it having a tendency to derange the digestive and milk-secreting organs.

5. Corn meal was without effect on the composition of the milk.

6. There was but little change in the composition of the milk produced by Herd I. for a period of six months, during which time the herd received the same or so-called standard ration; a gradual increase in the percentage of solids not fat only was noted.

7. Corn gluten meal and corn meal were without noticeable influences on the chemical composition of the butter fat.

8. The addition of corn oil to the corn gluten meal ration caused a depression of 10 points in the saponification equiva-

lent, a decrease of $3\frac{1}{2}$ points in the Reichert-Meissl number, and an increase of 9 points in the iodine number, while the melting point of the fat remained unchanged.

9. An analysis of the butter fat will seldom give positive knowledge concerning the firmness or body of the butter.

10. A high iodine number is indicative of a soft or "light-bodied" butter; but a high melting point is not a sure indication of a hard, firm butter.

11. It seems probable that neither the proteid or carbohydrate groups, when fed in normal amounts, have any noticeable influence in changing the proportions of the several milk ingredients, or in modifying the chemical character of the butter fat; such changes, so far as they occur, are due to the presence of the oil in the feed stuff.

12. Corn gluten meal with a minimum percentage of oil produced rather a soft, yielding butter; this condition was noticeably increased by the addition of corn oil to the ration.

13. The flavor of butter depends primarily on the cleanliness of the milk, stage of lactation of the animal, method of butter manufacture, and especially upon the character of the starter employed. Normal feeding stuffs are of secondary importance in establishing butter flavor.[1]

14. The present and previous experiments indicate that starchy feeds produce a hard-bodied butter, vegetable oils a soft butter; some proteids a hard-bodied butter, others butter of a softer, lighter body.

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[1] A possible exception to the above may be made in the case of young, clean pasture grass.

B. Digestion Experiments with Sheep.

J. B. LINDSEY.[1]

Digestion experiments with sheep were begun at this station in 1893, and a full description of the method employed will be found in the eleventh report of the Massachusetts State Experiment Station. The following experiments were made in the autumn of 1902 and during the winter and spring of 1903. The full data is given in this report, with the exception of the daily production of manure and the daily water consumption, in which case, to economize space, averages only are presented.

The periods extended over fourteen days, the first seven of which were preliminary, collection of fæces being made during the last seven. Ten grams of salt were fed each sheep daily, in addition to the regular ration. Water was before the animals at all times. Sheep III. throughout the series gave evidence of strong digestive powers, while Sheep II. and particularly Sheep I. showed at times evidence of weak digestion, and in several cases the results from these two latter sheep were omitted, and the tests will be repeated. The sheep were full-grown grade Southdown wethers, and have been used for a number of years.

Composition of Feed Stuffs (Per Cent.).

[Dry matter.]

FEED STUFFS.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Digestion hay,	7.63	12.03	31.60	45.89	2.85
Apple pomace,	3.93	5.06	16.17	70.00	4.84
Biles XXXX distillers' grains,	1.77	37.75	14.56	34.15	11.77
Merchants distillers' grains,	2.10	34.52	13.71	35.25	14.42
Brewers' grains,	3.83	26.02	17.48	45.30	7.37
Malt sprouts,	4.97	28.27	16.24	49.02	1.50
Soy bean meal,	5.18	41.93	4.40	29.43	19.06
Hominy meal,	3.38	12.23	4.97	69.43	9.99
Waste, Sheep III., Period XXV.,	7.63	12.03	31.60	45.89	2.85

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[1] With E. B. Holland and P. H. Smith.

Composition of Fæces (Per Cent.).

Sheep I.

Period.	FÆCES FROM—	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XX., .	Digestion hay, ...	10.63	11.65	31.88	42.46	3.38
XXI., .	Apple pomace, ...	9.57	13.98	29.32	42.40	4.73
XXII., .	Biles XXXX distillers' grains,	10.26	18.28	26.85	41.40	3.21
XXIII., .	Merchants distillers' grains, .	10.63	18.34	27.04	40.81	3.18
XXIV., .	Brewers' grains, . . .	9.94	11.65	28.73	46.98	2.70

Sheep II.

Period.	FÆCES FROM—	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XX., .	Digestion hay, ...	12.08	12.10	28.74	43.45	3.63
XXI., .	Apple pomace, ...	10.58	14.23	26.89	42.70	5.60
XXII., .	Biles XXXX distillers' grains,	10.80	19.13	24.54	42.29	3.24
XXIII., .	Merchants distillers' grains, .	11.79	18.78	23.90	41.94	3.59
XXIV., .	Brewers' grains, . . .	11.46	12.59	26.14	46.78	3.03
XXVII., .	Soy bean meal, ...	13.41	14.22	24.83	43.40	4.14

Sheep III.

Period.	FÆCES FROM—	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
XX., .	Digestion hay, ...	12.34	13.71	26.72	43.29	3.94
XXI., .	Apple pomace, ...	11.08	15.63	25.75	42.08	5.46
XXII., .	Biles XXXX distillers' grains,	10.88	19.60	23.92	42.25	3.35
XXIII., .	Merchants distillers' grains, .	11.64	19.53	23.61	41.76	3.46
XXIV., .	Brewers' grains, . . .	11.18	12.29	25.19	48.00	3.34
XXV., .	Malt sprouts, ...	12.82	15.06	24.35	44.27	3.50
XXVII., .	Soy bean meal, ...	12.75	14.28	26.81	41.67	4.49
XXVIII., .	Hominy meal, ...	13.06	14.88	24.06	43.41	4.59

Dry Matter Determinations made at the Time of Weighing out the Different Foods, and Dry Matter in Air-dry Manure (Per Cent.).

Sheep I.

PERIOD.	Digestion Hay.	Apple Pomace.	Biles XXXX Distillers' Grains.	Merchants Distillers' Grains.	Brewers' Grains.	Malt Sprouts.	Soy Bean Meal.	Hominy Meal.	Waste.	Air-dry Manures.
XX., .	85.59	–	–	–	–	–	–	–	–	90.50
XXI., .	86.60	18.56	–	–	–	–	–	–	–	90.48
XXII., .	86.75	–	90.10	–	–	–	–	–	–	94.66
XXIII., .	87.22	–	–	91.23	–	–	–	–	–	93.24
XXIV., .	87.60	–	–	–	84.31	–	–	–	–	93.12

Dry Matter Determinations made at the Time of Weighing out the Different Foods, and Dry Matter in Air-dry Manure (Per Cent.) — Concluded.

Sheep II.

PERIOD.	Digestion Hay.	Apple Pomace.	Biles XXXX Distillers' Grains.	Merchants Distillers' Grains.	Brewers' Grains.	Malt Sprouts.	Soy Bean Meal.	Hominy Meal.	Waste.	Air-dry Manures.
XX., .	85.59	–	–	–	–	–	–	–	–	90.32
XXI., .	86.60	18.56	–	–	–	–	–	–	–	90.21
XXII., .	86.75	–	90.10	–	–	–	–	–	–	94.74
XXIII., .	87.22	–	–	91.23	–	–	–	–	–	93.15
XXIV., .	87.60	–	–	–	84.31	–	–	–	–	93.00
XXVII., .	87.82	–	–	–	–	–	–	–	–	93.23

Sheep III.

XX., .	85.59	–	–	–	–	–	–	–	–	90.12
XXI., .	86.60	18.56	–	–	–	–	–	–	–	89.78
XXII., .	86.75	–	90.10	–	–	–	–	–	–	94.02
XXIII., .	87.22	–	–	91.23	–	–	–	–	–	93.11
XXIV., .	87.60	–	–	–	84.31	–	–	–	–	93.32
XXV., .	89.12	–	–	–	–	85.55	–	–	73.50	93.56
XXVII., .	87.82	–	–	–	–	–	86.62	–	–	93.40
XXVIII., .	88.25	–	–	–	–	–	–	88.48	–	92.91

Average Daily Amount of Manure excreted and Water drank (Grams).

Period.	Character of Ration.	Sheep I.			Sheep II.			Sheep III.		
		Manure excreted Daily.	Sample Air Dry.	Water drank Daily.	Manure excreted Daily.	Sample Air Dry.	Water drank Daily.	Manure excreted Daily.	Sample Air Dry.	Water drank Daily.
XX.,	Digestion hay,	680	31.96	1,815	590	30.49	1,451	628	30.07	1,640
XXI.,	Apple pomace,	703	29.14	518	528	27.69	382	501	25.78	313
XXII.,	Biles XXXX distillers' grains,	654	28.38	1,690	595	27.98	1,097	671	27.41	1,410
XXIII.,	Merchants distillers' grains,	632	27.46	1,758	600	26.72	1,091	722	26.88	1,531
XXIV.,	Brewers' grains,	741	32.86	2,214	707	30.81	1,142	636	29.04	1,694
XXV.,	Malt sprouts,	1,090	31.33	1,623	933	31.51	1,053	721	26.83	1,286
XXVII.,	Soy bean meal,	674	27.78	2,500	617	24.58	2,208	638	26.05	2,316
XXVIII.,	Hominy meal,	700	28.73	2,500	825	26.25	2,017	637	23.14	2,198

Weights of Animals at Beginning and End of Period (Pounds).

Period.	Character of Ration.	Sheep I.		Sheep II.		Sheep III.	
		Beginning.	End.	Beginning.	End.	Beginning.	End.
XX.,	Digestion hay,	158.75	155.00	150.25	146.25	140.00	139.00
XXI.,	Apple pomace,	153.00	152.00	144.75	146.25	138.00	138.50
XXII.,	Biles XXXX distillers' grains,	152.50	153.50	147.00	146.75	139.50	137.00
XXIII.,	Merchants distillers' grains,	152.50	153.00	148.50	148.25	136.75	139.25
XXIV.,	Brewers' grains,	161.25	155.75	153.25	150.50	144.75	142.75
XXV.,	Malt sprouts,	159.75	156.75	155.25	152.50	145.50	146.25
XXVII.,	Soy bean meal,	154.25	152.00	154.75	154.50	149.00	146.50
XXVIII.,	Hominy meal,	156.75	152.00	157.25	156.50	150.25	149.00

Digestion Hay. — Period XX.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
900 grams hay fed,	770.31	58.77	92.67	243.42	353.50	21.95
319.59 grams manure excreted,	289.23	30.75	33.70	92.21	122.81	9.78
Grams digested,	481.08	28.02	58.97	151.21	230.69	12.17
Per cent. digested,	62.45	47.68	63.63	62.12	65.26	55.44

Sheep II.

900 grams hay fed,	770.31	58.77	92.67	243.42	353.50	21.95
304.86 grams manure excreted,	275.35	33.26	33.32	79.13	119.64	10.00
Grams digested,	494.96	25.51	59.35	164.29	233.86	11.95
Per cent. digested,	64.25	43.41	64.04	67.49	66.16	54.44

Sheep III.

900 grams hay fed,	770.31	58.77	92.67	243.42	353.50	21.95
300.70 grams manure excreted,	270.99	33.44	37.15	72.41	117.31	10.68
Grams digested,	499.32	25.33	55.52	171.01	236.19	11.27
Per cent. digested,	64.82	43.10	59.91	70.25	66.81	51.34
Average per cent. digested (three sheep),	**63.84**	**44.73**	**62.53**	**66.62**	**66.08**	**53.74**

Average nutritive ratio of rations for three sheep, 1 : 7.29.

Apple Pomace. — Period XXI.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams hay fed,	519.60	39.65	62.51	164.19	238.44	14.81
1,200 grams apple pomace fed,	222.72	8.75	11.27	36.01	155.90	11.79
Total consumed,	742.32	48.40	73.78	200.20	394.34	26.60
291.36 grams manure excreted,	263.62	25.23	36.85	77.29	111.77	12.47
Amount digested,	478.70	23.17	36.93	122.91	282.57	14.13
Minus hay digested,	332.54	17.84	39.38	110.01	157.37	8.00
Apple pomace digested,	146.16	5.33	–	12.90	125.20	6.13
Per cent. digested,	65.63	60.91	–	35.82	80.31	51.99

Sheep II.

Total consumed as above,	742.32	48.40	73.78	200.20	394.34	26.60
276.90 grams manure excreted,	249.79	26.43	35.55	67.17	106.66	13.99
Amount digested,	492.53	21.97	38.23	133.03	287.68	12.61
Minus hay digested,	332.54	17.84	39.38	110.01	157.37	8.00
Apple pomace digested,	159.99	4.13	–	23.02	130.31	4.61
Per cent. digested,	71.83	47.20	–	63.93	83.59	39.10

Sheep III.

Total consumed as above,	742.32	48.40	73.78	200.20	394.34	26.60
257.81 grams manure excreted,	231.46	25.65	36.18	59.60	97.40	12.64
Amount digested,	510.86	22.75	37.60	140.60	296.94	13.96
Minus hay digested,	332.54	17.84	39.38	110.01	157.37	8.00
Apple pomace digested,	178.32	4.91	–	30.59	139.57	5.96
Per cent. digested,	80.06	56.11	–	84.95	89.53	50.56
Average per cent. digested (three sheep),	**72.51**	**54.74**	–	**61.57**	**84.48**	**47.22**

Average nutritive ratio of rations for three sheep, 1 : 12.02.

Biles Distillers' Grains. — Period XXII.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams hay fed,	563.88	43.02	67.83	178.19	258.76	16.07
250 grams Biles distillers' grains fed,	225.25	3.99	85.03	32.80	76.92	26.51
Total consumed,	789.13	47.01	152.86	210.99	335.68	42.58
283.76 grams manure excreted,	268.61	27.56	49.10	72.12	111.20	8.62
Amount digested,	520.52	19.54	103.76	138.87	224.48	33.96
Minus hay digested,	360.88	19.36	42.73	119.39	170.78	8.68
Biles distillers' grains digested,	159.64	–	61.03	19.48	53.70	25.28
Per cent. digested,	70.87	–	71.77	59.39	69.31	95.36

Sheep II.

Total consumed as above,	789.13	47.01	152.86	210.99	335.68	42.58
279.77 grams manure excreted,	265.05	28.63	50.70	65.04	112.09	8.59
Amount digested,	524.08	18.38	102.16	145.95	223.59	33.99
Minus hay digested,	360.88	19.36	42.73	119.39	170.78	8.68
Biles distillers' grains digested,	163.20	–	59.43	26.56	52.81	25.31
Per cent. digested,	72.45	–	69.39	80.98	68.66	95.48

Sheep III.

Total consumed as above,	789.13	47.01	152.86	210.99	335.68	42.58
274.09 grams manure excreted,	257.70	28.04	50.51	61.64	108.88	8.63
Amount digested,	531.43	18.97	102.35	149.35	226.80	33.95
Minus hay digested,	360.88	19.36	42.73	119.39	170.78	8.68
Biles distillers' grains digested,	170.55	–	59.62	29.96	56.02	25.27
Per cent. digested,	75.71	–	70.12	91.34	72.83	95.32
Average per cent. digested (three sheep),	**73.01**	–	**70.59**	**77.24**	**70.43**	**95.39**

Average nutritive ratio of rations for three sheep, 1:4.34.

Merchants Distillers' Grains.— Period XXIII.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams hay fed,	566.93	43.26	68.20	179.15	260.16	16.16
250 grams merchants distillers' grains fed,	228.08	4.79	78.73	31.27	80.40	32.89
Total consumed,	795.01	48.05	146.93	210.42	340.56	49.05
274.64 grams manure excreted,	256.07	27.22	46.96	69.24	104.50	8.14
Amount digested,	538.94	20.83	99.97	141.18	236.06	40.91
Minus hay digested,	362.84	19.47	42.97	120.03	171.71	8.73
Merchants distillers' grains digested,	176.10	1.36	57.00	21.15	64.35	32.18
Per cent. digested,	77.21	28.39	72.40	67.64	80.04	97.84

Sheep II.

Total consumed as above,	795.01	48.05	146.93	210.42	340.56	49.05
267.16 grams manure excreted,	248.86	29.34	46.74	59.48	104.37	8.93
Amount digested,	546.15	18.71	100.19	150.94	236.19	40.12
Minus hay digested,	362.84	19.47	42.97	120.03	171.71	8.73
Merchants distillers' grains digested,	183.31	–	57.22	30.91	64.48	31.39
Per cent. digested,	80.37	–	72.68	98.85	80.20	95.44

Sheep III.

Total consumed as above,	795.01	48.05	146.93	210.42	340.56	49.05
268.76 grams manure excreted,	250.24	29.13	48.87	59.08	104.50	8.66
Amount digested,	544.77	18.92	98.06	151.34	236.06	40.39
Minus hay digested,	362.84	19.47	42.97	120.03	171.71	8.73
Merchants distillers' grains digested,	181.93	–	55.09	31.31	64.35	31.66
Per cent. digested,	79.77	–	69.97	100.00	80.04	96.26
Average per cent. digested (three sheep),	**79.12**	–	**71.68**	**88.83**	**80.09**	**96.51**

Average nutritive ratio of rations for three sheep, 1:4.78.

Dried Brewers' Grains. — Period XXIV.

Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
500 grams hay fed,	438.00	33.42	52.69	138.41	201.00	12.48
400 grams brewers' grains fed,	337.24	12.92	87.75	58.95	152.77	24.85
Total consumed,	775.24	46.34	140.44	197.36	353.77	37.33
328.61 grams manure excreted,	306.00	30.42	35.65	87.91	143.76	8.26
Amount digested,	469.24	15.92	104.79	109.45	210.01	29.07
Minus hay digested,	280.32	15.04	33.19	92.73	132.66	6.74
Brewers' grains digested,	188.92	.88	71.60	16.72	77.35	22.33
Per cent. digested,	56.02	–	81.60	28.36	50.63	89.36

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Total consumed as above,	775.24	46.34	140.44	197.36	353.77	37.33
308.06 grams manure excreted,	286.50	32.83	36.07	74.89	134.02	8.68
Amount digested,	488.74	13.51	104.37	122.47	219.75	28.65
Minus hay digested,	280.32	15.04	33.19	92.73	132.66	6.74
Brewers' grains digested,	208.42	–	71.18	29.74	87.09	21.91
Per cent. digested,	61.80	–	81.12	50.45	57.01	88.17

Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Total consumed as above,	775.24	46.34	140.44	197.36	353.77	37.33
290.43 grams manure excreted,	271.03	30.30	33.31	68.27	130.09	9.05
Amount digested,	504.21	16.04	107.13	129.09	223.68	28.28
Minus hay digested,	280.32	15.04	33.19	92.73	132.66	6.74
Brewers' grains digested,	223.89	1.00	73.94	36.36	91.02	21.54
Per cent. digested,	66.39	–	84.26	61.68	59.58	86.68
Average per cent. digested (three sheep),	**61.40**	–	**82.33**	**46.83**	**55.74**	**88.24**

Average nutritive ratio of rations for three sheep, 1:4.14.

Malt Sprouts. — Period XXV.

Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
700 grams English hay fed,	623.84	47.60	75.05	197.13	286.28	17.78
42.14 grams waste hay,	30.97	2.36	3.73	9.79	14.21	.88
Total hay consumed,	592.87	45.24	71.32	187.34	272.07	16.90
200 grams malt sprouts fed,	171.10	8.50	48.37	27.79	83.87	2.57
Total consumed,	763.97	53.74	119.69	215.13	355.94	19.47
268.33 grams manure excreted,	251.05	32.18	37.81	61.13	111.14	8.79
Amount digested,	512.92	21.56	81.88	154.00	244.80	10.68
Minus hay digested,	379.44	20.36	44.93	125.52	179.57	9.13
Malt sprouts digested,	133.48	1.20	36.95	28.48	65.23	1.55
Per cent. digested,	78.01	–	76.39	102.50	77.78	60.31

Nutritive ratio of ration for Sheep III., 1:5.16.

Soy Bean Meal. — Period XXVII.

Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
700 grams hay fed,	614.74	46.90	73.95	194.26	282.10	17.52
200 grams soy bean meal fed,	173.24	8.97	72.64	7.62	50.98	33.02
Total consumed,	787.98	55.87	146.59	201.88	333.08	50.54
245.80 grams manure excreted,	229.16	30.73	32.59	56.90	99.46	9.49
Amount digested,	558.82	25.14	114.00	144.98	233.62	41.05
Minus hay digested,	393.43	21.11	46.59	130.15	186.19	9.46
Soy bean meal digested,	165.39	4.03	67.41	14.83	47.43	31.59
Per cent. digested,	95.46	44.93	92.80	194.62	93.04	95.67

Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Total consumed as above,	787.98	55.87	146.59	201.88	333.08	50.54
260.47 grams manure excreted,	243.28	31.02	34.74	65.22	101.37	10.92
Amount digested,	544.70	24.85	111.85	136.66	231.71	39.62
Minus hay digested,	393.43	21.11	46.59	130.15	186.19	9.46
Soy bean meal digested,	151.27	3.74	65.26	6.51	45.52	30.16
Per cent. digested,	87.32	41.70	89.34	85.43	89.29	91.34
Average per cent. digested (two sheep),	**91.39**	**43.32**	**91.07**	**140.03**	**91.17**	**93.51**

Average nutritive ratio of rations for two sheep, 1:4.11.

Hominy Meal. — Period XXVIII.

Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams hay fed,	529.50	40.40	63.70	167.32	242.99	15.09
300 grams hominy meal fed,	265.44	8.97	32.46	13.19	184.29	26.52
Total consumed,	794.94	49.37	96.16	180.51	427.28	41.61
231.44 grams manure excreted,	215.03	28.08	32.00	51.74	93.34	9.87
Amount digested,	579.91	21.29	64.16	128.77	333.94	31.74
Minus hay digested,	338.88	18.18	40.13	112.10	160.37	8.15
Hominy meal digested,	241.03	3.11	24.03	16.67	173.57	23.59
Per cent. digested,	90.80	34.67	74.03	126.55	94.18	88.95

Nutritive ratio of ration for Sheep III., 1:8.32.

Summary of Coefficients.

RATION.	Sheep Number.	Dry Matter.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
Hay,	Sheep I.,	62.45	47.68	63.63	62.12	65.26	55.44
	Sheep II.,	64.25	43.41	64.04	67.49	66.16	54.44
	Sheep III.,	64.82	43.10	59.91	70.25	66.81	51.34
Average,		**63.84**	**44.73**	**62.53**	**66.62**	**66.08**	**53.74**
Apple pomace,	Sheep I.,	65.63	60.91	–	35.82	80.31	51.99
	Sheep II.,	71.83	47.20	–	63.93	83.59	39.10
	Sheep III.,	80.06	56.11	–	84.95	89.53	50.56
Average,		**72.51**	**54.74**	–	**61.57**	**84.48**	**47.22**
Biles distillers' grains,	Sheep I.,	70.87	–	71.77	59.39	69.31	95.36
	Sheep II.,	72.45	–	69.39	80.98	68.66	95.48
	Sheep III.,	75.71	–	70.12	91.34	72.83	95.32
Average,		**73.01**	–	**70.59**	**77.24**	**70.43**	**95.39**
Merchants distillers' grains,	Sheep I.,	77.21	28.39	72.40	67.64	80.04	97.84
	Sheep II.,	80.37	–	72.68	98.85	80.20	95.44
	Sheep III.,	79.77	–	69.97	100.00	80.04	96.26
Average,		**79.12**	–	**71.68**	**88.83**	**80.09**	**96.51**
Dried brewers' grains,	Sheep I.,	56.02	–	81.60	28.36	50.63	89.36
	Sheep II.,	61.80	–	81.12	50.45	57.01	88.17
	Sheep III.,	66.39	–	84.26	61.68	59.58	86.68
Average,		**61.40**	–	**82.33**	**46.83**	**55.74**	**88.24**
Malt sprouts,	Sheep III.,	**78.01**	–	**76.39**	**102.50**	**77.78**	**60.31**
Soy bean meal,	Sheep II.,	95.46	44.93	92.80	194.62	93.04	95.67
	Sheep III.,	87.32	41.70	89.34	85.43	89.29	91.34
Average,		**91.39**	**43.32**	**91.07**	**140.03**	**91.17**	**93.51**
Hominy meal,	Sheep III.,	**90.80**	**34.67**	**74.03**	**126.55**	**94.18**	**88.95**

Discussion of the Results.

Digestion Hay. — The hay was largely Kentucky blue-grass (*Poa pratensis*), cut in bloom, and was employed in all of the several tests herein reported. It showed a high degree of digestibility.

Apple Pomace. — The pomace was taken fresh from the cider mill, and contained 18.56 per cent. of dry matter. It is the first digestion test of such material on record, either in Europe or the United States. The sheep did not digest it as evenly as could be desired, although they ate it satisfactorily, and no digestion disturbances were noted. The percentage of crude protein (5.06 in dry matter) was small, and no coefficients were obtained. This, in all probability, was partly due to the "digestion depression" known to take place when feeds especially high in carbohydrates are added to a hay ration, the effect being particularly noticeable in the protein, and to a less extent in the fiber. The pomace contained fully as much digestible matter as silage made from the smaller varieties of corn. Whether, per unit of dry matter, it is as valuable a feed as corn silage, is rather uncertain. This point will be ascertained later.

Distillers' Dried Grains. — Considerable has been said concerning the source, composition and digestibility of distillers' grains in the thirteenth report of this station. Briefly stated, these feeds represent the residue in the manufacture of alcohol, spirits and whiskey from the several cereals, and are composed chiefly of the hull, germ and protein matter of the grains. In the better class of such material, containing 28 or more per cent. of protein, the residue consists largely of corn. In the most modern plants, the distillery slop, hot from the stills, is dried immediately in especially constructed driers, and has a slightly sour taste and smell. One of the two samples herein reported — the merchants — had a slightly burned taste, which is not to be desired. The grains are now sold in Massachusetts markets under the following names: Biles XXXX Grains, Ajax Flakes, Merchants Grains, Hall's AAAA Grains, Atlas Gluten Meal and Corn Protegran.

Both samples here reported showed a high degree of digestibility. The sample of Merchants grains proved about 6 per cent. more digestible than the "Fourex" brand, due probably to the character of the cereals used in the mash. The difference was principally in the extract matter. Comparing the coefficients obtained with Sheep III., the difference in case of the total dry matter is reduced to 4 per cent. Marked differences are observed in the digestibility of the fiber. Such variations in fiber digestibility are characteristic of all grains and grain by-products. This matter will be referred to farther on.

In this connection it will doubtless prove of interest to summarize the results obtained at this station with 7 different samples of distillers' grains: —

Composition of the Grains (Per Cent.).

BRAND.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Biles X, ...	8.91	1.68	29.15	9.58	40.03	10.65
Biles XX, ...	9.53	2.44	25.49	11.22	41.80	9.52
Biles XXX, ...	7.46	2.05	29.86	10.28	38.52	11.83
Biles XXXX, . . .	8.83	1.70	34.76	11.40	33.50	9.81
Biles XXXX, . . .	9.45	1.55	35.46	13.00	29.87	10.67
Merchants, ...	8.77	1.92	31.49	12.51	32.15	13.16
Atlas, ...	8.96	.94	38.80	8.86	28.08	14.36
Average, . . .	8.84	1.75	32.14	10.98	34.85	11.43

The percentage of ash is low, as would naturally be expected. Its exact character has not been determined. The protein percentage is relatively high, and varies considerably, depending upon the material used. The brands offered in Massachusetts have been guaranteed to contain 33 and 34 per cent. Considerable fiber is present, as a result of the incorporated grain hulls. The fiber and extract matter must show a very considerable amount of pentosans, although determinations have not been made. The fat percentage is quite high, being similar in quantity to that contained in the corn gluten feed, before the corn oil was extracted.

Digestion Coefficients of Distillers' Dried Grains (Per Cent.).

[All experiments.]

NUMBER OF SHEEP.	Brand.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Sheep I.,	Biles X grains,	86.50	20.24	65.51	130.11	93.12	93.94
Sheep III.,	Biles X grains,	87.07	–	80.05	127.56	85.15	97.60
Sheep I.,	Biles XX grains,	88.53	13.91	79.94	122.75	88.22	94.45
Sheep VI.,	Biles XX grains,	79.77	–	76.50	97.22	79.77	94.87
Sheep II.,	Biles XXX grains,	79.88	–	73.41	108.91	78.03	91.78
Sheep VI.,	Biles XXX grains,	71.41	–	74.01	66.03	72.69	93.95
Sheep I.,	Biles XXXX grains,	79.82	–	72.08	102.77	81.12	96.99
Sheep VI.,	Biles XXXX grains,	73.47	–	69.22	81.78	76.73	98.45
Sheep I.,	Biles XXXX grains,	70.87	–	71.77	59.39	69.31	95.36
Sheep II.,	Biles XXXX grains,	72.45	–	69.39	80.98	68.66	95.48
Sheep III.,	Biles XXXX grains,	75.71	–	70.12	91.34	72.83	95.32
Sheep IV.,	Merchants grains,	77.21	28.39	72.40	67.64	80.04	97.84
Sheep V.,	Merchants grains,	80.37	–	72.68	98.85	80.20	95.44
Sheep VI.,	Merchants grains,	79.77	–	69.97	100.00	80.04	96.26
Sheep III.,	Atlas gluten meal,	79.53	–	73.04	94.88	84.00	92.43
Sheep IV.,	Atlas gluten meal,	79.75	–	72.56	116.50	84.91	90.06
Average,	. . . . .	78.88	–	72.67	96.67	79.68	95.01

As a result of 16 single digestion trials with 6 different samples, several points may be noted: —

(*a*) The dry matter coefficients differed considerably, but the grains showed a high average digestibility.

(*b*) The ash was apparently little digested. Whether this was literally true, or whether a portion of it was substituted for the digestible ash of the hay, is not clear.

(*c*) The protein in the several brands was quite evenly digested, except in the first two samples.

(*d*) The fiber showed marked variations in digestibility, in common with all feeds of similar character. While it has been generally held that nitrogenous feed stuffs do not affect the normal digestibility of the coarse fodders they supplement, it certainly seems reasonable to conclude that the addition of 200 to 250 grams of the distillers' grains to the hay ration, giving a nutritive ration of 1 : 4, has resulted in increasing the digestibility of the fiber in the hay; which accounts, in the majority of cases, for the apparently very high digestion coefficients obtained. Admitting this to be the case, the fact still remains that, while the digestion coefficient for the fiber is rather of an uncertain quantity, it must be regarded as relatively high.

(*e*) The extract matter digested in the several samples differed to a noticeable extent, depending probably upon the nature of the material composing it, the way in which it is united with the crude fiber, and also upon the digestive capacity of the sheep. Other things being equal, animals in normal condition should digest substantially equal quantities of the same feed stuff, when fed under similar conditions. It often happens, however, that one or the other animal will be a trifle out of condition without giving any external evidence of it, and hence will digest rather more of one fodder group and less of another.

Attention is called to the fact that the higher the digestion coefficients obtained for the fiber, the higher are those obtained for the extract. This is undoubtedly due to the intimate chemical and physiological relations known to exist between these two fodder groups.

(*f*) The fat was quite evenly and largely digested.

Dried Brewers' Grains. — These were grains of good quality, and of a fresh, bright color. Sheep I. showed its inability to digest the fiber and extract matter as well as the other sheep, and even Sheep II. did not utilize the fiber as well as Sheep III. The average coefficients for the three sheep corresponded quite well with former experiments made at this station, and also with German experiments; excepting that in case of the American tests the coefficients for the protein and fiber are somewhat higher, and the extract matter 4 per cent. lower.

Malt Sprouts. — These were of average quality. They contained an exceptionally large portion of their nitrogen, 42.29 per cent., in the form of amids. The experiment was conducted with three sheep, but Sheep I. and Sheep II. digested so much less fiber and extract matter than is customary that the results with these two sheep were discarded, and the test will be repeated. Only one other American test with a single animal is on record, and showed considerably less fiber and extract matter digested than that obtained in the present experiment. The present single test agrees fairly well with the seven German trials reported.

Soy Bean Meal (*Brook's Medium Green*). — This variety is by far the best suited to northern conditions. The sample was grown upon the station grounds, and was coarsely ground before being fed. The seed is green in color, and similar in size to dwarf garden peas. The bean contained 61 per cent. of protein and fat, and these two ingredients are shown to be 91 and 93 per cent. digestible. The extract matter, 29.43 per cent., was 91 per cent. digested. The coefficients of digestibility obtained for the fiber are, of course, incorrect, due probably to the favorable influence of the soy bean, a nitrogenous feed stuff, in increasing the digestibility of the hay carbohydrates. It can be assumed that the fiber contained in the soy bean has a high rate of digestibility. The small amount present, 4.40 per cent., renders a knowledge of the exact percentage digestible of minor importance.

The three American digestion trials, with an unnamed variety, reported in Lindsey's compilation, show the protein and fat to have been nearly as well digested as those in the present trial. The fiber and extract matter, on the other hand, had noticeably lower digestion coefficients (33 and 71). In the two German trials reported the protein and fat are respectively 87 and 94 per cent., and the extract matter 62 per cent. digestible, while the digestibility of the fiber is not stated.

It is evident, from all trials thus far made, that the protein and fat, comprising from 50 to 60 per cent. of the bean is very fully digested. Whether the high digestibility of the fiber and extract in the present experiment is due to the variety of the bean, or is a peculiarity of the sheep employed, will be determined by further tests.

Hominy Meal, or Chop. — As used for cattle feeding this consists of the hull, germ and some of the gluten and soft starch. The sample tested for digestibility was of good average quality. The present trial was made with three sheep, but Sheep I. and Sheep II. digested so unevenly that the results were discarded, it being evident that their digestion powers had become weakened by continued use. The results with Sheep III. show the hominy to be fully as digestible as corn meal. The addition to the hay of even a carbohydrate feed, such as hominy, seemed to have increased the digestibility of the fiber in the hay, judging from the coefficients obtained for the hominy fiber.

C. Raising Dairy Calves without Milk.

J. B. LINDSEY.

With plenty of skim milk available, the rearing of calves intended for the dairy is a comparatively simple matter. There is, however, a constantly increasing demand in Massachusetts for whole milk, and the amount available for butter production is likely to diminish from year to year. With little or no skim milk at his disposal, the dairyman desirous of growing his own young stock is in need of a milk substitute to feed the calf during the first four to six months of its life. The brief experiment here reported was made to test the efficacy, for such a purpose, of Hayward's and Blatchford's calf meals.

(1) *Hayward's Calf Meal.*

Hayward of the Pennsylvania experiment station studied the question of providing a cheap and suitable milk substitute, and published his results in Bulletin No. 60 of that station. He succeeded in rearing ten unselected grade Guernsey calves without the aid of milk after the first fourteen to eighteen days. Most of the calves weighed from 150 to 250 pounds when from four to five months old, and were produced at a food cost of from $8 to $9 each. He concluded that the calf meal was a fairly satisfactory milk substitute, if used judiciously by careful feeders, but that it was not equal to whole milk.

The formula proposed by Hayward for the meal was as follows: —

	Pounds.
Wheat flour,	30
Cocoanut meal,	25
Nutrium,	20
Linseed meal,	10
Dried blood,	2

Hayward employed whole wheat, grown at the station and ground by the local miller. In the test about to be reported St. Louis flour at a cost of 2 cents a pound was used.

Cocoanut meal is a by-product in the manufacture of cocoanut oil, and was obtained of the India Product Food Company, 50 Chatham Street, Boston, Mass. It has a decided cocoanut odor, and tested 21.11 per cent. of protein and 19.23 per cent. of fat. Cocoanut oil is likely to become rancid after a brief period. Hayward believed it to have quite a favorable effect as a part of the calf meal.

Nutrium is a powder prepared by the National Nutrient Company of Jersey City, N. J., and is simply skim milk evaporated at a low temperature. It was very dry and fine, and kept well. This company also puts out the same article in granular form, but the powder is to be preferred.

Dried blood, especially prepared for feeding purposes, is offered by the Armour Fertilizer Works and by Swift & Co. of Chicago. It is also to be had of the agricultural warehouses in the large cities. It was employed by Hayward to check scours.

Cost per Pound of Each Ingredient and of the Mixture.

	Pounds.	Cost (Cents).	Total.
Wheat flour,	30	2	$0 60
Cocoanut meal,	25	1½	38
Nutrium,	20	10	2 00
Linseed meal,	10	1½	15
Blood,	2	4[1]	08
	87	–	$3 21

[1] In small quantities.

The cost per pound figures 3.7 cents, and to this must be added the freight charges on the nutrium, cocoanut meal and blood. Those who are desirous of trying this mixture would, of course, purchase these ingredients in larger quantities than the above, but it is doubtful if the meal could be prepared for much less than 4 cents a pound.

Method of Feeding the Meal. — This station tested the calf meal, using two unselected thrifty grade Jersey calves, a bull and a heifer. The several ingredients were in such good mechanical condition that it was not necessary to grind the mixture. It may not be out of place to add that the meal should be fine, and free from any coarse particles.

One pound was thoroughly stirred into 8 pounds of very hot water, and allowed to stand until milk-warm, in which condition it was fed. Hayward used 6 pounds of water to a pound of meal, and employed a calf feeder; but in our case it was considered better to teach the animals to drink at once.

The calves were fed whole milk for the first nine to fourteen days, and then skim milk and calf meal gradually substituted, whole milk being entirely taken away at the end of three weeks. Three quarts of skim milk were fed daily, in addition to the calf meal, until the calves were four or five weeks old, when both calves were placed upon an entire diet of calf meal. Hayward used the calf meal entirely after the first ten days, but it seemed wiser to the writer to allow some milk for a longer period, and thus give the animals a better start. Three-fourths of a pound of the meal was fed at first, and the amount gradually increased, until at the close of the experiment Calf I. was receiving 3 pounds and Calf II. 2 pounds of the meal daily.

Average Daily Record of Each Calf.

	Days entirely on Milk.	Average Amount Daily (Quarts).	DAYS PARTLY ON MILK, PARTLY ON MEAL (AMOUNT DAILY).		
			Days.	Milk (Quarts).	Meal (Pounds).
Calf I.,	14	5.7	19	4.3	1
Calf II.,	9	5.3	15	4.3	1

Average Daily Record of Each Calf — Concluded.

	DAYS ENTIRELY ON MEAL (AMOUNT).		DAYS PARTLY ON MILK AFTER FEEDING MEAL AS ENTIRE RATION.		TOTAL CONSUMED.	
	Days.	Amount (Pounds.)	Days.	Milk (Quarts).	Milk (Quarts).	Meal (Pounds).
Calf I.,	143	2.50	2	4.0	152 [1]	374.0
Calf II.,	101	2.20	44	2.6	229 [2]	306.5

[1] Whole milk, 93 quarts; skim milk, 59 quarts.

[2] Whole milk, 69 quarts; skim milk, 160 quarts.

Effect of the Calf Meal. — No serious trouble was experienced with either calf until February 12, when Calf II. suffered a bad attack of indigestion, which rendered it necessary to take away a considerable portion of the meal and substitute skim milk; and this animal was still receiving some milk when the experiment terminated, although she recovered and made good gains. On January 5 the supply of cocoanut meal became exhausted, and flour middlings was used in its place until March 10. The continued use of the middlings may have been a partial cause of the trouble. Calf I. was rather more robust, and experienced only a slight digestion disturbance about the middle of February, when a portion of the meal was replaced by skim milk for two days. While the calves did not have as sleek an appearance as animals raised on a whole milk diet, they were certainly in a thrifty growing condition, and at the close of the trial appeared especially vigorous.

Weekly Weights of Calves (Pounds).

DATES.	Calf I.	Calf II.	DATES.	Calf I.	Calf II.
November 10,	95 [1]	85 [2]	February 2,	190	182
November 17,	105	95	February 9,	203	191
November 24,	110	97	February 16,	210	177 [3]
December 1,	115	105	February 23,	222	185
December 8,	122	112	March 2,	235	185
December 15,	130	120	March 9,	247	197
December 22,	142	130	March 16,	252	218
December 29,	147	135	March 23,	263	225
January 5,	157	145	March 30,	277	235
January 12,	–	–	April 6,	295	250
January 19,	167	152	April 13,	310	260
January 26,	170	170			

[1] Just after beginning calf meal, three weeks after birth.

[2] Just after beginning calf meal, two and one-half weeks after birth.

[3] Ill with indigestion.

It will be seen from the above tables that the calves made a fair growth during the experiment, especially during the last month of the trial. Calf I. weighed 310 pounds when six months old, and made an average daily growth of 1.4 pounds while receiving the calf meal; while Calf II. weighed 260 pounds when five and one-half months old, and gained 1.1 pounds daily on the calf meal.

Cost of Feed Consumed. — Allowing 3 cents a quart for the whole milk, ½ cent a quart for the skim milk and 4 cents a pound for the calf meal, the food cost in case of Calf I. was $20.20, and in case of Calf II. $15.11. If the calves had been fed largely calf meal at the end of the second week, this cost would have been somewhat reduced. Again, the calves might have been transferred a month earlier to a hay and grain diet. The object, however, in the present test was not to ascertain the minimum cost of raising the calf, but rather to note the effect of the calf meal during the first five or six months of the animal's life.

Conclusions. — 1. It is evident that, with reasonable care and cleanliness, calves can be successfully reared on Hayward's calf meal.

2. The meal is to be preferred only when a supply of skim milk is not available, or as a substitute for a portion of the milk.

3. The cost[1] is likely to be somewhat greater than when skim milk can be had at two cents a gallon. The expense of the meal is largely due to the nutrium, yet it is doubtful if a mixture as satisfactory for young calves could be obtained without the use of this substance.

4. The meal is evidently better utilized by calves after they are three months old than before that period.

5. The best method to be employed would probably be to allow the calf to suck the cow for the first two days, then feed whole milk for five days, to be followed by half whole and half skim milk for a week, gradually reducing the whole milk, so that at the beginning of the fourth week the diet may consist of 3 quarts of skim milk and $\frac{3}{4}$ to one pound of the meal, dissolved in the necessary hot water. At the end of the fourth week the skim milk may be dropped, and the calf put upon a diet of 2 pounds of the calf meal a day. Slight modifications may be made in this method depending on the condition of the animal.

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[1] The writer has grown seven unselected young calves, having an average weight when three days old of 73 pounds, to an average weight when ten weeks old of 173 pounds, on skim milk, together with such common grains as corn meal, wheat flour, flour middlings and gluten feed, at an average food cost of $4.80 each. By this method of feeding, calves ought to be produced that will weigh 200 to 300 pounds when five months old, at a food cost not exceeding $9 or $10. (See eleventh report of Massachusetts State Experiment Station, p. 125.)

6. It may be possible to modify the meal by replacing the cocoanut meal with some more common feeding stuffs, although Hayward did not succeed in finding a satisfactory substitute.

(2) *Blatchford's Calf Meal.*

This material, put out by the Barwell Mills, at Waukegan, Ill., is highly recommended by the manufacturers as a milk substitute. It is composed principally of linseed meal, beans, carob beans, cotton-seed meal and fenugreek, and retails at 3½ cents a pound. It has a very pronounced odor and flavor.

How the Meal was fed. — This article was tested by feeding it to one rugged grade Holstein calf, dropped Dec. 11, 1902. Unfortunately, the detailed record of the early part of this test has been lost, although some notes are on hand. The calf was first fed whole milk, a little later whole and skim milk, and at the end of two or three weeks the calf meal gradually substituted. The calf at first objected to the odor or taste of the meal, and never seemed to thoroughly relish it, although no serious difficulty was found in inducing the animal to take it. One pound of the meal was added to 6 pounds of hot water, thoroughly stirred and fed milk-warm. It was not possible to place the calf entirely upon the meal for a considerable time, hence the daily feed consisted of 4 quarts of skim milk and 2 pounds of the calf meal with the necessary water. On March 23, when a little over three months old, the calf was receiving 2¾ pounds of the meal daily, and continued to take this quantity without other food until the experiment terminated, May 4, the calf then being approximately four and one-half months old.

Weight of the Calf.

	Pounds.
March 23 (first record),	203.5
March 30,	205.0
April 6,	214.5
April 13,	221.0
April 20,	232.0
April 27,	242.0
May 14,	251.0

The animal did not suffer any serious digestion disturbances, and certainly grew well, as the above weights indicate, making an average increase of 1.15 pounds daily during the last forty-two days of the test.

Conclusions. — The above single trial is not sufficient to enable one to draw any absolute conclusions. The writer, however, observed the calf closely during the trial, and believes he is justified in making the following statements: —

1. Blatchford's calf meal is hardly as satisfactory as the Hayward mixture during the first three months of the calf's life, and it will probably prove necessary to feed one-third skim or whole milk and two-thirds meal during this period.

2. Used as above indicated, it proved quite satisfactory in the present single trial, can undoubtedly be depended upon as a partial milk substitute for calves under three months of age, and can be used as the entire food after that time and until the animal is ready for hay and the more common grains (five to six months).

3. It is possible that delicate calves would not thrive as well upon the meal as the one in the present trial.

4. The Blatchford meal was in good mechanical condition, and cannot be considered especially expensive.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.

Assistants: HENRI D. HASKINS, JAMES E. HALLIGAN, RICHARD H. ROBERTSON.

Part I. — Report on Official Inspection of Commercial Fertilizers.
Part II. — Report on General Work in the Chemical Laboratory.

Part I. — Report on Official Inspection of Commercial Fertilizers and Agricultural Chemicals during the Season of 1903.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 64; of these, 35 have offices for the general distribution of their goods in Massachusetts, 8 in New York, 8 in Connecticut, 3 in Vermont, 1 in Rhode Island, 3 in Canada, 1 in New Jersey, 1 in Maryland, 2 in Ohio, 1 in Illinois and 1 in Arkansas.

Three hundred and six brands of fertilizer, including chemicals, have been licensed in the State during the year. Five hundred and eighty-four samples of fertilizer have thus far been collected in the general markets by experienced assistants in the station.

Five hundred and twelve samples were analyzed at the close of November, 1903, representing two hundred and ninety distinct brands of fertilizer. These analyses were published in two bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 90, July, and No. 92, November, 1903.

During the year 1903 a larger number of fertilizers have been licensed in the State of Massachusetts than for any previous year in the history of our fertilizer inspection laws. This necessitates an increased amount of work in the official inspection of commercial fertilizers. Twenty-three more brands of fertilizers were licensed and eighty more collected during the past season than in the previous year.

Below will be found an abstract of the results of analyses of official commercial fertilizers for the years 1902 and 1903: —

	1902.	**1903.**
(*a*) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee,	7	7
Number with two elements above the highest guarantee, . . .	20	19
Number with one element above the highest guarantee, ...	83	91
Number with three elements between the lowest and highest guarantee,	183	207
Number with two elements between the lowest and highest guarantee,	87	118
Number with one element between the lowest and highest guarantee,	54	42
Number with three elements below the lowest guarantee, . . .	3	2
Number with two elements below the lowest guarantee, ...	18	24
Number with one element below the lowest guarantee, ...	67	100
(*b*) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee, . . .	10	2
Number with one element above the highest guarantee, ...	22	17
Number with two elements between the lowest and highest guarantee,	16	31
Number with one element between the lowest and highest guarantee,	13	13
Number with two elements below the lowest guarantee, ...	4	1
Number with one element below the lowest guarantee, ...	19	14
(*c*) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee, ...	9	11
Number between lowest and highest guarantee, ...	14	13
Number below lowest guarantee, ...	20	18

From the above table it will be seen that there is no material change in the quality of the fertilizers which have been examined, when compared with the results of the previous year. Where a discrepancy has occurred between the results of analysis and the manufacturers' guarantee, we are of the opinion that poor mixing is responsible, rather than a disposition on the part of the manufacturer to furnish an inferior article. As proof of this, we find in most cases that wherever a fertilizer shows a low test in any one ingredient, a corresponding high test is shown on some other element of plant food in the same brand; this usually corrects any difference in commercial value of the fertilizer.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1902 and 1903 (Cents per Pound).

	1902.	1903.
Nitrogen in ammonia salts,	16.50	17.50
Nitrogen in nitrates,	15.00	15.00
Organic nitrogen in dry and fine-ground fish, meat, blood and in high-grade mixed fertilizers.	16.50	17.00
Organic nitrogen in fine bone and tankage,	16.00	16.50
Organic nitrogen in medium bone and tankage,	12.00	12.00
Phosphoric acid soluble in water,	5.00	4.50
Phosphoric acid soluble in ammonium citrate,	4.50	4.00
Phosphoric acid in fine-ground fish, bone and tankage,	4.00	4.00
Phosphoric acid in cotton-seed meal, castor pomace and wood ashes,	4.00	4.00
Phosphoric acid in coarse fish, bone and tankage,	3.00	3.00
Phosphoric acid insoluble (in water and in ammonium citrate) in mixed fertilizers.	2.00	2.00
Potash as sulfate (free from chlorides),	5.00	5.00
Potash as muriate,	4.25	4.25

A comparison of the above trade values of fertilizing ingredients for the years 1902 and 1903 shows a higher market cost of nitrogen in form of ammonia salts and in the higher grades of organic substances for the year 1903 than for the previous year; this is, however, largely offset by a corresponding decrease in the market cost of the better forms of phosphoric acid.

The schedule of trade values for 1903 was adopted by representatives of the Massachusetts, Connecticut, Rhode Island, Maine, Vermont and New Jersey experiment stations, at a conference held during the month of March, 1903; it is based on the condition of the fertilizer market in centres of distribution in New England, New York and New Jersey during the six months preceding March, 1903, and refers to the current market prices of the leading standard raw materials which furnish nitrogen, phosphoric acid and potash, and which enter largely into the manufacture of our commercial fertilizers.

Table A, following, gives the average analysis of officially collected fertilizers for 1903 ; Table B gives a compilation of analyses, showing the maximum, minimum and average percentages of the different essential elements of plant food in so-called special crop fertilizers put out by different manufacturers.

TABLE A. — *Average Analysis of Officially Collected Fertilizers for 1903.*

NATURE OF MATERIAL.	Moisture.	NITROGEN IN ONE HUNDRED POUNDS.		PHOSPHORIC ACID IN ONE HUNDRED POUNDS.							POTASSIUM OXIDE IN ONE HUNDRED POUNDS.	
							TOTAL.		AVAILABLE.			
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
Complete fertilizers,	10.70	2.96	2.77	4.43	3.81	2.33	10.57	8.87	8.24	7.44	5.48	5.19
Ground bones,	7.69	3.23	2.85	-	9.88	14.86	24.74	22.54	9.88	-	-	-
Tankage,	8.04	4.59	3.93	-	10.68	7.54	18.22	17.96	10.68	10.00	-	-
Dissolved bone-black,	12.80	-	-	12.09	3.21	1.56	16.86	16.00	15.30	15.00	-	-
Acid phosphate,	10.30	-	-	14.90	1.70	-	16.60	-	16.60	-	-	-
Wood ashes,	13.05	-	-	-	-	-	1.44	1.50	-	-	5.56	5.00
Cotton-seed meal,	7.41	6.73	7.00	-	-	-	-	-	-	-	-	-
Flax meal,	9.42	5.73	6.08	-	-	-	-	-	-	-	-	-
Nitrate of soda,	2.06	15.41	15.41	-	-	-	-	-	-	-	-	-
Sulfate of ammonia,	.78	20.40	19.00	-	-	-	-	-	-	-	-	-
High-grade sulfate of potash,	1.15	-	-	-	-	-	-	-	-	-	48.88	48.12
Muriate of potash,	2.69	-	-	-	-	-	-	-	-	-	48.98	-
Kainit,	2.70	-	-	-	-	-	-	-	-	-	11.20	12.00

TABLE B. — *Compilation of Analyses of Commercial Fertilizers for the Year 1903.*

NAME OF FERTILIZER.	Moisture.	NITROGEN IN ONE HUNDRED POUNDS.			TOTAL PHOSPHORIC ACID IN ONE HUNDRED POUNDS.			AVAILABLE PHOSPHORIC ACID IN ONE HUNDRED POUNDS.			POTASSIUM OXIDE IN ONE HUNDRED POUNDS.		
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
Corn fertilizer,	10.70	3.70	1.25	2.24	14.82	8.92	11.29	12.88	5.34	8.85	9.56	1.52	3.64
Fruit and vine fertilizer,	9.94	2.69	2.00	2.48	12.98	9.10	10.99	10.34	7.24	8.78	11.28	6.06	8.11
Grain fertilizer,	10.28	8.13	1.25	3.94	18.04	7.52	11.74	12.88	4.32	8.69	14.60	2.06	5.78
Grass fertilizer,	9.03	8.13	2.23	4.24	18.04	4.22	9.88	11.84	2.68	6.86	14.60	2.18	6.04
Market-garden fertilizer,	9.82	4.54	2.08	3.45	13.90	6.12	10.63	10.85	5.32	8.06	10.82	2.30	6.81
Potato fertilizer,	10.25	5.02	1.07	2.51	13.90	7.08	10.43	9.69	5.02	8.24	10.58	2.12	5.51
Tobacco fertilizer,	9.42	5.94	.59	3.41	13.38	4.22	10.00	10.56	2.94	7.54	17.34	1.66	7.96
Onion fertilizer,	9.26	4.36	1.16	2.64	12.26	6.38	8.72	9.70	5.10	6.56	7.76	4.04	5.76

A careful study of Table B teaches the following lessons. The trade name of a fertilizer is a poor criterion in ascertaining the efficiency of a fertilizer. Many farmers depend too much on trade names in making their selection of fertilizers. With the great variety of fertilizers now found upon the market, it becomes no easy matter for the average farmer to make an intelligent and judicious selection of his fertilizers, unless he is in possession and makes use of the fertilizer bulletins which are issued from time to time. In making a selection of a fertilizer for growing special crops, the needs of the soil and the requirements of the crop should receive careful consideration, and a fertilizer should be selected which will supply the wants of the soil in the most suitable and economical manner. In deciding what brands of fertilizers to purchase for general use, it is self-evident that those fertilizers should be selected which furnish the greatest amount of nitrogen, phosphoric acid and potash in a suitable and available form for the same money.

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State during the Past Year (May 1, 1903, to May 1, 1904) and the Brands licensed by Each.

The American Agricultural Chemical Co., Boston, Mass.: —
  High-grade Fertilizer with Ten Per Cent. Potash.
  Grass and Lawn Top-dressing.
  Tobacco Starter and Grower.
  Brightman's Fish and Potash.
  Fine-ground Bone.
  Columbia Fish and Potash.
  Abattoir Bone.
  Dissolved Bone-black.
  Muriate of Potash.
  Double Manure Salt.
  High-grade Sulfate of Potash.
  Nitrate of Soda.
  Dry Ground Fish.
  Plain Superphosphate.
  Sulfate of Ammonia.
  Kainit.

The American Agricultural Chemical Co. (Bradley Fertilizer Co., branch), Boston, Mass.: —
  Bradley's Complete Manure for Potatoes and Vegetables.
  Bradley's Complete Manure for Corn and Grain.
  Bradley's Complete Manure with Ten Per Cent. Potash.

The American Agricultural Chemical Co. (Bradley Fertilizer Co., branch), Boston, Mass. — *Con.*
  Bradley's Complete Top-dressing for Grass and Grain.
  Bradley's X L Superphosphate.
  Bradley's Potato Manure.
  Bradley's Potato Fertilizer.
  Bradley's Corn Phosphate.
  Bradley's Eclipse Phosphate.
  Bradley's Niagara Phosphate.
  Bradley's English Lawn Fertilizer.
  Church's Fish and Potash.
  Bradley's Seeding-down Manure.

American Agricultural Chemical Co. (H. J. Baker & Bro., branch), New York, N. Y.: —
  Baker's A A Ammoniated Superphosphate.
  Baker's Complete Potato Manure.

The American Agricultural Chemical Co. (Clark's Cove Fertilizer Co., branch), Boston, Mass.: —
  Clark's Cove Bay State Fertilizer.
  Clark's Cove Bay State Fertilizer G. G.
  Clark's Cove Great Planet Manure.
  Clark's Cove Potato Manure.

The American Agricultural Chemical Co. (Clark's Cove Fertilizer Co., branch), Boston, Mass. — *Con.*
- Clark's Cove Potato Fertilizer.
- Clark's Cove King Philip Guano.

The American Agricultural Chemical Co. (Crocker Fertilizer and Chemical Co., branch), Buffalo, N. Y.: —
- Crocker's Potato, Hop and Tobacco Phosphate.
- Crocker's Corn Phosphate.
- Crocker's A A Complete Manure.

The American Agricultural Chemical Co. (Cumberland Bone Phosphate Co., branch), Boston, Mass.: —
- Cumberland Superphosphate.
- Cumberland Potato Fertilizer.

The American Agricultural Chemical Co. (L. B. Darling Fertilizer Co., branch), Pawtucket, R. I.: —
- Darling's Blood, Bone and Potash.
- Darling's Complete Ten Per Cent. Manure.
- Darling's Potato Manure.
- Darling's Farm Favorite.
- Darling's General Fertilizer.

The American Agricultural Chemical Co. (Great Eastern Fertilizer Co., branch), Rutland, Vt.: —
- Northern Corn Special.
- Vegetable Vine and Tobacco.
- Garden Special.
- General.
- Grass and Oat Fertilizer.

The American Agricultural Chemical Co. (Pacific Guano Co., branch), Boston, Mass.: —
- Pacific High-grade General.
- Pacific Potato Special.
- Soluble Pacific Guano.
- Pacific Nobsque Guano.

The American Agricultural Chemical Co. (Packers' Union Fertilizer Co., branch), Rutland, Vt.: —
- Gardners' Complete Manure.
- Animal Corn Fertilizer.
- Potato Manure.
- Universal Fertilizer.
- Wheat, Oats and Clover Fertilizer.

The American Agricultural Chemical Co. (Quinnipiac Co., branch), Boston, Mass.: —
- Quinnipiac Market-garden Manure.
- Quinnipiac Phosphate.
- Quinnipiac Potato Manure.
- Quinnipiac Potato Phosphate.
- Quinnipiac Corn Manure.

The American Agricultural Chemical Co. (Quinnipiac Co., branch), Boston, Mass. — *Con.*
- Quinnipiac Climax Phosphate.
- Quinnipiac Havana Tobacco Grower.
- Quinnipiac Onion Manure.

The American Agricultural Chemical Co. (Read Fertilizer Co., branch), New York, N. Y.: —
- Read's Practical Potato Special.
- Read's Farmers' Friend.
- Read's Standard.
- Read's High-grade Farmers' Friend.
- Read's Vegetable and Vine.

The American Agricultural Chemical Co (Standard Fertilizer Co., branch), Boston, Mass.: —
- Standard Complete Manure.
- Standard Fertilizer.
- Standard Special for Potatoes.
- Standard Guano.

The American Agricultural Chemical Co. (H. F. Tucker & Co., branch), Boston, Mass.: —
- Tucker's Original Bay State Bone Superphosphate.
- Tucker's Special Potato.

The American Agricultural Chemical Co. (Williams & Clark Fertilizer Co., branch), Boston, Mass.: —
- Williams & Clark's High-grade Special.
- Williams & Clark's Americus Potato.
- Williams & Clark's Potato Phosphate.
- Williams & Clark's Potato Manure.
- Williams & Clark's Corn Phosphate.
- Williams & Clark's Royal Bone Phosphate.
- Williams & Clark's Prolific Crop Producer.

The American Agricultural Chemical Co. (M. E. Wheeler & Co., branch), Rutland, Vt.: —
- Corn Fertilizer.
- Potato Manure.
- Havana Tobacco Grower.
- Superior Truck Fertilizer.
- Bermuda Onion Grower.
- Grass and Oats Fertilizer.

W. H. Abbott, Holyoke, Mass.: —
- Abbott's Animal Fertilizer.
- Abbott's Eagle Brand.
- Abbott's Tobacco Fertilizer.

Abbott and Martin Rendering Co., Columbus, O.: —
- Harvest King.
- Abbott's Tobacco and Potato Special.

The American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.
- Cotton-seed Hull Ashes.

The American Linseed Co., New York, N. Y.: —
- Cleveland Flax Meal.

Armour Fertilizer Works, Baltimore, Md.: —
- Grain Grower.
- Bone, Blood and Potash.
- High-grade Potato.
- All Soluble.
- Ammoniated Bone with Potash.
- Bone Meal.

H. J. Baker & Bro., New York, N. Y.: —
- Baker's Pure Castor Pomace.

Berkshire Fertilizer Co., Bridgeport, Conn.: —
- Berkshire Complete Fertilizer.
- Berkshire Ammoniated Bone Phosphate.
- Berkshire Potato and Vegetable Phosphate.

T. H. Bunch, Little Rock, Ark.: —
- Cotton-seed meal.

Beach Soap Co., Lawrence, Mass.: —
- Beach's Advance Brand.
- Beach's Universal Brand.

Joseph Breck & Sons, Boston, Mass.: —
- Breck's Lawn and Garden Dressing.
- Breck's Market-garden Manure.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures.
- Bowker's Hill and Drill Phosphate.
- Bowker's Farm and Garden Phosphate.
- Bowker's Lawn and Garden Dressing.
- Bowker's Potato and Vegetable Manure.
- Bowker's Fish and Potash (Square Brand).
- Bowker's Potato and Vegetable Phosphate.
- Bowker's Sure Crop Phosphate.
- Gloucester Fish and Potash.
- Bowker's High-grade Fertilizer.
- Bowker's Bone and Wood Ash Fertilizer.
- Bowker's Fish and Potash (D Brand).
- Bowker's Corn Phosphate.
- Bowker's Bone, Blood and Potash.
- Bowker's Early Potato Manure.
- Bowker's Soluble Animal Fertilizer.
- Bowker's Tobacco Starter.
- Bowker's Tobacco Ash Fertilizer.

Bowker Fertilizer Co., Boston, Mass. — *Con.*
- Bowker's Market-garden Manure.
- Bowker's Potash Bone.
- Bowker's Ten Per Cent. Manure.
- Bowker's Kainit.
- Bowker's Complete Mixture.
- Bowker's Ammoniated Food for Flowers.
- Bristol Fish and Potash.
- Bowker's Fine-ground Fish.
- Bowker's Tobacco Ash Elements.
- Bowker's Ground Bone.
- Bowker's Wood Ashes.
- Bowker's Superphosphate.
- Sulfate of Ammonia.
- Nitrate of Soda.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulfate of Potash.
- Dried Blood.

Chicopee Rendering Co., Springfield, Mass.: —
- Pure Ground Bone.
- Tankage.
- Complete Animal Fertilizer or Lawn and Garden Dressing.

Chas. M. Cox & Co., Boston, Mass.: —
- Cotton-seed Meal.

E. Frank Coe Co., New York, N. Y.: —
- E. Frank Coe's High-grade Ammoniated Bone Superphosphate.
- E. Frank Coe's Gold Brand Excelsior Guano.
- E. Frank Coe's Bay State Phosphate.
- E. Frank Coe's Tobacco and Onion Fertilizer.
- E. Frank Coe's Excelsior Potato Fertilizer.
- E. Frank Coe's Fish Guano and Potash (F. P.).
- E. Frank Coe's Columbian Corn Fertilizer.
- E. Frank Coe's Columbian Potato Fertilizer.
- E. Frank Coe's New Englander Corn Fertilizer.
- E. Frank Coe's New Englander Potato Fertilizer.
- E. Frank Coe's Columbian Ammoniated Bone Superphosphate.
- E. Frank Coe's Red Brand Excelsior Guano.
- E. Frank Coe's Ground Bone.
- American Farmers' Market-garden Special.
- American Farmers' Complete Potato.
- American Farmers' Corn King.

John C. Dow & Co., Boston, Mass.: —
- Dow's Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
- Chemicals for Imperial Liquid Plant Food.
- Chemicals for Liquid Grass Fertilizer.

Wm. E. Fyfe & Co., Clinton, Mass.: —
- Canada Ashes (Star Brand).

R. & J. Farquhar & Co., Boston, Mass.: —
- Clay's London Fertilizer.

F. E. Hancock, Walkerton, Ontario, Can.: —
- Pure Unleached Canada Hard-wood Ashes.

The Hardy Packing Co., Chicago, Ill.: —
- Hardy's Tankage, Bone and Potash.
- Hardy's Tobacco and Potato Special.
- Hardy's Complete Manure.

Hargraves Manufacturing Co., Fall River, Mass.: —
- Fine-ground Bone and Tankage.

C. W. Hastings, Jamaica Plain, Mass.: —
- Ferti Flora.

Thomas Hersom & Co., New Bedford, Mass.: —
- Bone Meal.
- Meat and Bone.

John Joynt, Lucknow, Ontario, Can.: —
- Canada Hard-wood Ashes.

Lister's Agricultural Chemical Works, Newark, N. J.: —
- Lister's Success Fertilizer.
- Lister's Special Corn Fertilizer.
- Lister's Special Potato Fertilizer.
- Lister's Potato Manure.
- Lister's High-grade Special for Spring Crops.
- Lister's Animal Bone and Potash.

Lowell Fertilizer Co., Boston, Mass.: —
- Swift's Lowell Potato Phosphate.
- Swift's Lowell Potato Manure.
- Swift's Lowell Bone Fertilizer.
- Swift's Lowell Animal Brand.
- Swift's Lowell Ground Bone.
- Swift's Lowell Lawn Dressing.
- Swift's Lowell Market-garden Manure.
- Swift's Lowell Nitrate of Soda.

Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
- Potato Manure.
- Tobacco Starter Improved.
- Tobacco Manure Wrapper Brand.
- Economical Potato Manure.
- Average Soils Complete Manure.

Mapes Formula and Peruvian Guano Co., New York, N. Y. — *Con.*
- Vegetable Manure or Complete Manure for Light Soils.
- Corn Manure.
- Complete Manure (A Brand).
- Cereal Brand.
- Complete Manure Ten Per Cent. Potash.
- Top-dresser Improved, Half Strength.
- Tobacco Ash Constituents.
- Grass and Grain Spring Top-dressing.
- Complete Manure for General Use.
- Fruit and Vine Manure.
- Cauliflower and Cabbage Manure.
- Lawn Top-dressing.

D. M. Moulton, Monson, Mass.: —
- Ground Bone.

National Fertilizer Co., Bridgeport, Conn.: —
- Chittenden's Complete Fertilizer.
- Chittenden's High-grade Special for Tobacco.
- Chittenden's Market Garden.
- Chittenden's Potato Phosphate.
- Chittenden's Ammoniated Bone.
- Chittenden's Fish and Potash.

New England Fertilizer Co., Boston, Mass.: —
- New England Corn Phosphate.
- New England Potato Fertilizer.

Olds & Whipple, Hartford, Conn.: —
- Complete Tobacco Fertilizer.
- Vegetable Potash.

The Ohio Farmers' Fertilizer Co., Columbus, O.: —
- Corn, Oats and Wheat Fish Guano.
- Tobacco and Potato Special.
- High-grade Truck Guano.

Parmenter & Polsey Fertilizer Co., Boston, Mass.: —
- Plymouth Rock Brand.
- Special Potato.
- Star Brand.
- P. & P. Potato.
- A. A. Brand.
- Lawn Dressing.
- Special Fertilizer for Strawberries.
- Grain Grower.
- Acid Phosphate.
- Muriate of Potash.
- Nitrate of Soda.
- Sulfate of Potash.

R. T. Prentiss, Holyoke, Mass.: —
- Complete Fertilizers.

Benjamin Randall, Boston, Mass.: —
- Randall's Market Garden.
- Randall's Farm and Field.

Rogers Manufacturing Co., Rockfall, Conn.: —
- All Round Fertilizer.
- Complete Potato and Vegetable.
- High-grade Complete Corn and Grain.
- Fish and Potash Fertilizer.
- High-grade Soluble Tobacco and Potato.
- High-grade Fertilizer for Oats and Top-dressing.
- High-grade Grass and Grain.
- High-grade Soluble Tobacco Fertilizer.
- Pure Fine-ground Bone.

Rogers & Hubbard Co., Middletown, Conn.: —
- Hubbard's Oats and Top-dressing.
- Hubbard's Grass and Grain.
- Hubbard's Soluble Corn Manure.
- Hubbard's Soluble Potato Manure.
- Hubbard's Soluble Tobacco Manure.
- Hubbard's All Soils and All Crops.
- Hubbard's Corn Phosphate.
- Hubbard's Potato Phosphate.
- Hubbard's '02 Top-dressing.
- Hubbard's Raw Knuckle Bone Flour.
- Hubbard's Strictly Pure Fine Bone.

Ross Brothers, Worcester, Mass.: —
- Ross Brothers' Lawn Dressing.

Russia Cement Co., Gloucester, Mass.: —
- Essex Dry Ground Fish.
- Essex Complete Manure for Potatoes, Roots and Vegetables.
- Essex Complete Manure for Corn, Grain and Grass.
- Essex Market-garden and Potato Manure.
- Essex Corn Fertilizer.
- Essex A. I. Superphosphate.
- Essex X X X Fish and Potash.
- Essex Odorless Lawn Dressing.
- Essex Tobacco Starter.
- Essex Special Tobacco Manure.
- Essex Rhode Island Special Fertilizer.
- Essex High-grade Sulfate of Potash.
- Essex Nitrate of Soda.

Chas. Stevens, Napanee, Ontario, Can.: —
- Beaver Brand Ashes.

Salisbury Cutlery Handle Co., Salisbury, Conn.: —
- Pure Ground Bone.

Sanderson's Fertilizer and Chemical Co., New Haven, Conn.: —
- Sanderson's Formula A.
- Sanderson's Formula B.
- Sulfate of Potash.
- Sanderson's Old Reliable.
- Sanderson's Potato Manure.
- Sanderson's Corn Superphosphate,
- Sanderson's Special with Ten Per Cent. Potash.

Thomas L. Stetson, Randolph, Mass.: —
- Bone Meal.

W. H. Warren, Northborough, Mass.: —
- Fine-ground Bone.

Wilcox Fertilizer Works, Mystic, Conn.: —
- Wilcox Potato, Onion and Tobacco Manure.
- Wilcox Potato Manure.
- Wilcox Complete Bone Superphosphate.
- Wilcox Fish and Potash.
- Wilcox High-grade Tobacco Fertilizer.
- Wilcox Dry Ground Fish.

Sanford Winter, Brockton, Mass.: —
- Pure Ground Bone.

The Whitman & Pratt Rendering Co., Lowell, Mass.: —
- All Crops.
- Potato Plowman.
- Corn Success.
- Ground Bone.

J. M. Woodard & Bro., Greenfield, Mass.: —
- Tankage.

A. H. Wood & Co., South Framingham, Mass.: —
- Special Fertilizer for Corn, Potatoes, etc.
- Special Manure for Market Gardening, Top-dressing, etc.

PART II. — REPORT ON GENERAL WORK IN THE CHEMICAL LABORATORY.

C. A. GOESSMANN.

1. Analyses of materials forwarded for examination.
2. Notes on soil analyses.
3. Notes on wood ashes and lime ashes.
4. Notes on Peruvian guano.
5. Notes on sugar-beet refuse.
6. Notes on city garbage products.

1. ANALYSES OF MATERIALS FORWARDED FOR EXAMINATION.

During the season of 1903, 235 samples of fertilizing materials and miscellaneous substances have been received from farmers within our State for analysis. Many of these materials are refuse or by-products from some manufacturing industry. Some of these by-products contain only nitrogen, some contain phosphoric acid or possibly potash compounds, others contain two, and many of them contain all, of the essential elements of plant food. In either case the material possesses a distinct commercial value, which can be ascertained only by a careful chemical analysis.

As in the past, the investigation of materials for general fertilizing purposes has been carried on free of charge to farmers within our State. Our practice has been to analyze this class of materials in the order in which the samples arrive at this office. Beginning about April 1 and continuing through the summer and early fall, work of this nature has to give place to our official inspection work on commercial fertilizers. For this reason we would advise those sending samples for analysis free of charge to send as early in the season as possible. The winter season usually offers more time to attend to this kind of work, and therefore enables us to furnish results of analysis more promptly than at any other period of the year.

During the year we have taken an active part in the work of the Association of Official Agricultural Chemists, which aims to investigate any new modes of analysis in agricultural chemistry. The result of our labors along this line, as well as other investigation work of a technical nature, does not appear in our publications, as its chief value is in the establishment of new methods of analysis.

Following is a list of materials received during the past season : —

Wood ashes,	41	Dry ground fish,	6
Complete fertilizers,	34	Ground bones,	6
Soils,	70	Minerals,	12
Lime ashes,	10	Phosphatic slag,	4
Cotton-seed meal,	8	Nitrate of soda,	4
Dissolved bone-black,	2	Peat,	2
Tankage,	3	Tannery lime waste,	2
Cotton hull ashes,	2	Muriate of potash,	3
Superphosphate,	1	Cotton-seed dust,	1
High-grade sulfate of potash,	2	Cotton-seed droppings,	1
Cocoanut fiber pith,	1	Refuse ashes,	1
New York horse manure,	1	Sulfate of ammonia,	1
Sheep manure and wool waste,	1	Belgian phosphate,	1
Lime refuse,	1	Cassava waste,	1
Garbage tankage,	1	Manure,	1
Waste lime, plastering,	1	Mill refuse,	1
Acid phosphate,	1	Peruvian guano,	1
Coal and wood ashes,	1	Granite,	1
Sugar-beet refuse,	1	Bat guano,	1
Cotton waste,	1	Dried blood,	1
Lime,	1	Wool waste,	2

2. NOTES ON SOIL ANALYSES.

In the above list of materials which have been forwarded for analysis during the season we would call attention to the increased number of samples of soil which have been received, as compared with previous years. The information desired by parties sending soil samples for analysis is, in most cases, What are the necessary fertilizing ingredients to be applied to this particular soil, and in what proportion in order to produce successfully any given crop? We are trying to aid in answering this inquiry by every means within our power, and shall continue, as in the past, to analyze samples of soil; yet we must insist that the samples of soil forwarded for investigation are taken according to our instructions, which are of late published in every March bulletin of this division (see Bulletin No. 89, March, 1903), otherwise the analysis can be of little practical value. The information furnished by a chemical analysis of soil is still of an arbitrary nature, and furnishes only the amount of the various ingredients of plant food present in the soil, without reference to their availability to any particular plant. Knowing that our present methods for the determination of the availability of plant food in soils is not as satisfactory as could be desired, we are studying the subject continually, believing that more satisfactory ones can be secured only by a constant attention to the questions involved.

3. NOTES ON WOOD ASHES AND LIME ASHES.

(*a*) *Wood Ashes.* — During the season of 1903, 17.4 per cent. of the materials forwarded for analysis consisted of wood ashes, as against 24 per cent. for the year previous. The following compilation shows their general chemical character: —

Analysis of Wood Ashes.

	Number of Samples.
Moisture from 1 to 10 per cent.,	11
Moisture from 10 to 20 per cent.,	14
Moisture from 20 to 30 per cent.,	9
Moisture above 30 per cent.,	3
Potassium oxide above 8 per cent.,	2
Potassium oxide from 6 to 7 per cent.,	4
Potassium oxide from 5 to 6 per cent.,	8
Potassium oxide from 4 to 5 per cent.,	12
Potassium oxide from 3 to 4 per cent.,	8
Potassium oxide below 3 per cent.,	3
Phosphoric acid from 1 to 2 per cent.,	34
Phosphoric acid below 1 per cent.,	3
Average per cent. of calcium oxide (lime), 29.39.	
Insoluble matter below 10 per cent.,	7
Insoluble matter from 10 to 15 per cent.,	12
Insoluble matter from 15 to 20 per cent.,	9
Insoluble matter above 20 per cent.,	8

Table showing the Maximum, Minimum and Average Per Cents. of the Different Ingredients found in Wood Ashes for the Season of 1903.

	Maximum.	Minimum.	Average.
Moisture,	37.34	2.27	15.23
Potassium oxide,	8.15	1.68	4.76
Phosphoric acid,	1.80	.46	1.37
Calcium oxide,	35.75	22.33	29.39
Insoluble matter,	28.85	1.40	15.07

We advise farmers, before buying ashes, to ascertain if the party of whom they are to purchase is on record as having complied with our State laws, and holds a license for the sale of his article in Massachusetts. Protection by our State laws is only secured by patronizing dealers and importers who have complied with our laws for the regulation of the trade in commercial fertilizers.

There are indications that more care is taken by some of our importers in the collection and shipment of ashes than has been the case in the past. In some cases as high as 8 and 9 per cent. of potassium oxide has been guaranteed in carloads of ashes imported from Canada; this is 3 or 4 per cent. higher than the usual guarantee of this element. The importance of buying ashes on a specified guaranteed composition of each of the essential elements, — potash, phosphoric acid, and also lime — cannot be too strongly urged upon our farmers.

(*b*) *Lime Ashes.* — Judging from the increased number of samples of lime ashes that have been received during the season for analysis, this material is used more commonly than heretofore to furnish lime to those soils which require an application of this ingredient. Although being a valuable source of lime, it is well to remember that lime ashes are a refuse product in the production of burned lime, and are therefore apt to vary widely in chemical composition (see following table), depending largely upon the mode of handling as well as exposure to the weather. Lime ashes should therefore be bought on a statement of guarantee of the quantity of lime, potash and phosphoric acid which they contain. The small quantity of phosphoric acid in lime ashes is derived from the wood that is used in charging the kiln; the potash is derived partially from this same source and partially from the limestone; both of these elements are therefore apt to vary widely in different samples.

Table showing the Maximum, Minimum and Average Per Cents. of the Different Ingredients found in Lime Ashes for the Season of 1903.

	Maximum.	Minimum.	Average.
Moisture,	23.16	10.47	15.66
Potassium oxide,	3.32	.76	1.86
Phosphoric acid,	1.66	.03	.63
Calcium oxide,	55.44	32.42	41.15
Insoluble matter,	26.50	1.10	6.46

4. Notes on Peruvian Guano.

Analysis of Peruvian Guano recently introduced into our Markets.

	Per Cent.
Moisture,	17.10
Total phosphoric acid,	21.26
Soluble phosphoric acid,	2.81
Reverted phosphoric acid,	10.47
Insoluble phosphoric acid,	7.98
Potassium oxide,	4.20
Nitrogen,	3.23

The above-stated article has of late been again introduced into our markets; it is evidently a genuine sample of Peruvian guano, and of a valuable composition as a general fertilizer. As Peruvian guanos are known to vary more or less in regard to their chemical composition, they should always be bought and sold on a statement of their guaranteed composition. A detailed discussion of the occurrence of Peruvian guanos, their merits as a fertilizer and their historic importance with reference to the introduction of commercial fertilizers, will be found in the annual report of the inspector of commercial fertilizers to the Massachusetts State Board of Agriculture for the years 1875–76.

5. NOTES ON SUGAR-BEET REFUSE.

Analysis of Sugar-beet Refuse forwarded for Investigation.

	Per Cent.
Moisture,	7.70
Phosphoric acid,	none
Total potassium oxide,	9.72
Water soluble potassium oxide,	8.36
Total nitrogen,	6.39
Nitrogen as nitrates,	3.86
Nitrogen as ammoniates,	.05
Nitrogen in organic form,	2.48
Calcium oxide,	none
Sodium oxide,	7.00
Sulphuric acid,	2.82
Chlorine,	1.87
Carbonic acid,	none

The above material is a waste product from the sugar-beet industry; it is produced in the process of manufacturing alcohol from the beet-sugar molasses; it is rich in potash and nitrogen, and deserves special attention in the production of tobacco and other industrial crops. The successful introduction of the beet-sugar manufacture as a home industry already benefits our agricultural interests in many ways, as was predicted by the friends of the sugar-beet industry years ago.

6. NOTES ON CITY GARBAGE PRODUCTS.

Sample No. 1 represents what is known as garbage tankage; sample No. 2 represents the ashes from the cremation of city garbage.

Analysis of Garbage Products.

	PER CENT.	
	Sample No. 1.	Sample No. 2.
Moisture,	7.42	3.01
Potassium oxide,	none.	5.13
Total phosphoric acid,	6.06	8.77
Available phosphoric acid,	4.40	–*
Insoluble phosphoric acid,	1.66	–*
Nitrogen,	5.96	none.

* Not determined.

The above-mentioned materials are products obtained by hygienic treatment of city garbage. Sample No. 1 was obtained by heating the selected garbage in vats under pressure; by this method the fats are recovered; and the organic nitrogenous matter is preserved for use as a nitrogen source in fertilizers. In this process, however, the greater part of the potash and other salines are leached out. Sample No. 2 represents the product obtained by the cremation of city garbage. In this material the nitrogen has been sacrificed, but the potash is retained in the ashes. The products from both of these processes furnish valuable material for fertilizing purposes; they should always be bought and sold on a statement of guaranteed composition.

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD, H. T. FERNALD.

The entomological division during 1903 has continued its work along lines similar to those of preceding years. The correspondence has received careful attention, but has been less than usual, probably because fewer insects have made their presence felt, owing to the peculiar weather conditions of the spring and summer.

The experiments to determine a simple and successful treatment for the San José scale have been continued according to a plan which promises well, and which, so far as can be learned, has not been tried elsewhere in this country. Certain difficulties have arisen, however, and whether it will be possible to proceed with these experiments during 1904 cannot now be determined.

Much attention has been given to the collections of insects at the insectary during the year, and, as a result, they are now more nearly expressive of our present knowledge than ever before.

The card catalogue has now entirely outgrown the cases intended to contain it, thus rendering it less useful for reference, but it is hoped that this difficulty may be soon overcome.

It is a generally recognized fact that original investigation and publication are among the most important functions of an experiment station. That the entomological division of the station has not fallen behind in this portion of its duties is seen by the following list of articles on entomology published during the present year by persons working at the insectary, either for the station, or by those fitting themselves for that work: —

C. H. Fernald: "The Brown-tail Moth" (with A. H. Kirkland), under direction of the State Board of Agriculture, Boston, March, 1903; "Colour Blindness in Entomologists," Canadian Entomologist, July, 1903.

H. T. Fernald: "Orchard Treatment for the San José Scale," Bulletin No. 86, Hatch Experiment Station, February, 1903; "How shall we arrange our Collections?" Entomological News, April, 1903; "First Annual Report of the State Nursery Inspector," Agriculture of Massachusetts for 1902, June, 1903; "Plant Lice," Nature Leaflet No. 18, Massachusetts Board of Agriculture, July, 1903; "Some Important Scale Insects," Massachusetts Crop Report for September, October, 1903; "Notes on the Species of Isodontia," Canadian Entomologist, October, 1903; "The Plum Webbing Saw Fly" (with E. A. Back), Entomological News, November, 1903; "Two New Species of Sphex," Psyche, October–December, December, 1903.

Mrs. M. E. Fernald: "Notes on the Coccidæ," Canadian Entomologist, January, 1903; "Lepidosaphes *versus* Mytilaspis," Canadian Entomologist, April, 1903; "Catalogue of the Coccidæ of the World," Bulletin No. 88, Hatch Experiment Station, July, 1903.

H. J. Franklin: "Notes on Acanthothrips," Psyche, October–December, December, 1903.

A. W. Morrill: "Life History and Description of the Strawberry Aleyrodes," Canadian Entomologist, February, 1903; "Notes on some Aleyrodes from Massachusetts, with Description of New Species," Psyche, April, 1903; "Notes on the Early Stages of Corylophodes marginicollis Lec," Entomological News, May, 1903; "New Apoidea from Montana," Canadian Entomologist, August, 1903; "Notes on the Immature Stages of Some Tingitids of the Genus Corythuca," Psyche, August, 1903; "The Greenhouse Aleyrodes and the Strawberry Aleyrodes," Technical Bulletin No. 1, Hatch Experiment Station, August, 1903.

Besides these, several other papers are either in press or well advanced in preparation, and will soon be published.

Insects of the Year.

The present year has seen the great abundance of a few kinds of insects, but taken as a whole the season has been unfavorable for their rapid increase. The early spring was apparently normal in its character, but about the first of May a period of drought began, which continued well into June. During this period the grass dried up and in many places became brown and dead, and large numbers of insects were found clinging to it, having seemingly died of starvation. The result was that the hay crop, though late, was but little affected by insects; and similar results were more or less evident with nearly all crops, as regards their insect foes.

In a few cases, however, these weather conditions were favorable to insect life. The plant lice, which are usually destroyed in large numbers by cold spring rains, were this year almost entirely unchecked, and, increasing rapidly, did much injury to trees and plants already suffering from the lack of rain. The damage caused by plant lice was particularly noticeable on fruit stock, elms and maples, many of which suffered severely; and even when the heavy rains came later, destroying myriads of the lice, so many were present that large numbers survived, thus continuing the injury to more than an ordinary amount till quite late in the fall.

The spring weather also seemed to be unusually favorable for root maggots of various kinds, the onion maggot causing a large amount of loss to the onion growers in the Connecticut valley in particular, while the work of the cabbage maggot was seen everywhere. During the year more inquiries were received by this division about maggots than during the preceding eight years taken together.

The apple-tree tent-caterpillar was more abundant last spring than for a number of years, but whether the peculiar season has had the effect of destroying these insects sufficiently to prevent their appearance in large numbers in 1904 cannot now be determined.

The elm-leaf beetle began the season actively, and by May 21 their egg clusters were very abundant everywhere, but particularly on those trees which were not treated in 1902. Later in the season, however, their work was less noticeable than usual, and, in fact, there were many places where spraying seemed unnecessary. Whether the nature of the season or factors yet undiscovered were the cause of their slight importance is not known.

The San José scale has increased rapidly during the year, wherever it occurs. Crawling young were found last spring on June 9, nearly two weeks earlier than the year before, and during the summer and fall this insect seemed to increase in abundance more rapidly than usual.

During the year 1902 a new plum pest appeared in the Connecticut valley, spinning its webs entirely over the trees in May and early June. On investigation it proved to be a saw fly hitherto known only from South Dakota and Manitoba. Of this insect, which is known as *Neurotoma rufipes* Marl., the life history has been worked out at this station during the present year and published. While this insect has already shown great possibilities as a serious pest on the plum, it is too soon to predict that it will actually become such; but the results of the studies made here show that, if treated when it first appears, it should be easily controlled.

The plum curculio is always in evidence on the plums, and to some degree on the apples; but this year it has paid particular attention to the latter fruit, and by its punctures has reduced many thousands of bushels of apples from first class to a lower grade. Whether the unusually large amount of injury to apples by the curculio this year was due to a greater number of the insects which succeeded in passing through the preceding winter alive, or whether it was due to an insufficient supply of plums for them to attack last spring, is difficult to determine; possibly both factors occurred.

For several years the imported willow-borer (*Cryptorhynchus lapathi*) has been present in great abundance. The injuries which it causes to willows, poplars and similar soft-wooded trees are frequently serious; and it is now almost impossible to raise these trees in some localities, thus greatly reducing their value for planting as holders of the soil in such places as on sandy beaches. No satisfactory method of combating this insect has as yet been discovered.

The brown-tail moth has continued to enlarge its area of occupation, and it is only a question of time how soon it will be a pest all over New England.

The gypsy moth has now to a considerable extent recovered from the attacks made upon it by the State, which ceased in 1899, and in many places is as abundant as it ever was. A careful examination of a large part of the infested territory shows one change from former conditions; then, in towns not generally badly infested, the insect would be found in colonies, while elsewhere the trees and plants were not infested; at the present time the colonies in such towns are not as populous perhaps as formerly, but the insects are generally scattered, a few here and a few there, thus producing what may be termed a general distribution. This probably settles the possibility of extermination in the negative for the future. The State has lost its opportunity, and must abide by the results. No new important parasitic or predaceous foes have appeared thus far, and man must depend almost entirely on his own exertions to control this pest.

REPORT OF THE AGRICULTURISTS.

WM. P. BROOKS; ASSISTANT, F. R. CHURCH.

The agricultural department during the past season has followed up the main lines of inquiry pertaining to the selection of manures and fertilizers for the various crops of the field and garden previously undertaken. It is recognized that the inevitable variations due to seasonal and other conditions beyond control make necessary numerous repetitions of an experiment before results justify general conclusions. It is comparatively easy, for example, to determine whether a given fertilizer is useful to a given crop upon a given field in any one year. One is not, therefore, justified in concluding that it will prove useful every year; one does not know that it will prove useful in other combinations of fertilizer materials, nor even that its continued use may not ultimately prove harmful in certain directions.

Results must be tested by experiments again and again, and yet again, before the conditions affecting them can be estimated at their true value, safe deductions drawn therefrom that will be generally useful, or advice founded upon them. The past season, so exceptional in character, affords striking illustration of the necessity of such repetition in the nature of the results from the use of a number of materials which it was believed we quite fully understood. As a means of testing the results in plot experiments in the open field, where numerous conditions are beyond control, we have the past season continued the system of closed plot and vegetation experiments.

We have begun a series of experiments with asparagus, for which we have been making preparation for the past two years, having laid out forty-two plots for that purpose, with a view to seeking light as to the manurial needs of the crop, both as regards the selection and amount of materials required and the time of application. One-year-old plants of our own growing were set last spring, and have made a good start.

Forty-eight new varieties of potatoes have been given a preliminary trial, but will not be reported until after another year.

Our grass garden, with forty-eight species and seven varieties, has been thoroughly cared for, and one-half the plot of each species lawn-mowed throughout the season.

Exclusive of these plots of grass, our work has involved the care of two hundred and twenty-three plots in the open field and one hundred and fifty closed plots, while our vegetation experiments have required the care of two hundred and fifty-four plots.

The work with poultry has been of practically the same amount as in recent years, as we some time ago reached the limit with our present equipment. The study of the relations of feeds to egg production has engaged the greater share of the time devoted to this line of work.

In this report will be presented a statement of results obtained in a portion only of the plot experiments pertaining to the use of manures and fertilizers. Other results are reserved for discussion in bulletins which it is hoped may be published within the near future. A brief statement only will be made in this report of the general results obtained in our experiments with poultry.

The nature of the principal subjects of inquiry and the more important conclusions will be made clear by the following statement: —

I. — The relative value of barnyard manure, nitrate of soda, sulfate of ammonia and dried blood as sources of nitrogen. Soy beans, the crop of this year, gave yields on the basis of which the materials rank in the following order: barnyard manure, nitrate of soda, dried blood, sulfate of ammonia. The nitrate of soda ranks relatively lower this year than in most previous years, but the general average to date ranks the materials as follows, on the basis of increases in the crops as compared with the no-nitrogen plots: nitrate of soda, 100; barnyard manure, 77.8; dried blood, 65.1; sulfate of ammonia, 63.6.

II. — The relative value of muriate and high-grade sulfate of potash for field crops. The results of this year indicate the sulfate to be superior to the muriate for potatoes. For the soy beans the two salts gave nearly equal yields, while the crops of cabbages and onions were practical failures on both salts, largely, it is believed, because of the unfavorable season.

III. — *A.* The relative value of nitrate of soda, sulfate of ammonia, and dried blood, used in connection with manure, as sources of nitrogen for garden crops. The results indicate these materials used in amounts furnishing equal nitrogen to rank for this year in the following order: for the early crops, — including dandelions, strawberries, peas and beets, — dried blood, nitrate of soda, sulfate of ammonia; for the late crops, nitrate of soda ranks first, followed by dried blood and sulfate of ammonia. *B.* Relative value of sulfate and muriate of potash for garden crops. The results of the year indicate the sulfate of potash to be the better for strawberries, tomatoes, cucumbers, celery and turnips; while the muriate has given slightly superior results with dandelions, peas and beets.

IV. — The relative value of different potash salts for field crops. The salts under comparison are high-grade sulfate, low-grade sulfate, kainite, muriate, nitrate, carbonate and silicate. The crop of this year was clover, mixed with timothy. As indicated by the yields of clover, the best results were obtained on the high-grade sulfate; while the silicate, carbonate, low-grade sulfate and nitrate gave results almost as good. The yield of timothy was heaviest on the kainite and muriate. As last year, one of the most striking results of the experiment was the injury to the clover due to potash salts containing chlorine, — especially to the kainite.

V. — The relative value of phosphates used in quantities furnishing equal phosphoric acid to each plot. The crop of this year was cabbages, and those which gave satisfactory growth and yield in the order of their rank are: dissolved bone meal, South Carolina rock phosphate, raw bone meal, phosphatic slag, steamed bone meal, and dissolved boneblack. Three phosphates gave results much inferior to any of the others, viz., Tennessee phosphate, apatite, and Florida soft phosphate.

VI. — *A*. Soil test with corn. The crop of this year was very small on all plots, owing to the unfavorable season ; but the potash increased the crop to a far greater extent than any other plant-food element. *B*. Soil test with mixed grass and clover. The results demonstrate the close dependence of the grass crop upon the supply of nitrate of soda. They indicate also the increased tendency of continued use of nitrate and muriate of potash to bring the soil into an acid condition. Another marked result is the effect of an application of lime in increasing the proportion of timothy in a mowing sown to a mixture of timothy, red-top and clover.

VII. — To determine the economical result of using in rotation on grass lands : the first year, barnyard manure ; the second year, wood ashes ; and the third year, ground bone and muriate of potash. The average yield of hay, all three systems of manuring being represented, is at the rate of 8,104 pounds per acre in two crops. The average on that portion of the field reseeded last summer is on one plot at the rate of 8,546.5 pounds for the reseeded portion ; for the portion not reseeded, 6,243 pounds. On another plot the average yield on the reseeded portion is at the rate of 10,003 pounds, and on the portion not reseeded 5,642 pounds, per acre.

VIII. — Winter compared with spring application of manure. The field where this experiment is tried slopes moderately lengthwise of the plots. The crop this year was soy beans, and the crops under the two systems of application were not far from equal, but with the advantage slightly in favor of the winter over spring application. This result appears to have been due to the fact that the ground beneath its covering of snow remained unfrozen throughout the winter, and that there was practically no wash over the surface.

IX. — To determine the best nutritive ratio or the best mixture of feeds for laying hens. The results of the year appear to indicate that it is not essential to feed a mixture of feeds giving a narrow nutritive ratio for satisfactory egg production. They indicate, further, that the proportion of fat in the ration is a matter of much importance, a large proportion favoring egg production; and that, on the other hand, a large proportion of fiber in the ration, such as would be furnished when grains like oats and barley are largely used, is unfavorable to egg production. A ration in which corn is prominent has given results considerably superior to those obtained with the ration in which wheat is prominent; and the economic results in feeding corn largely in connection with a suitable amount of animal food are much superior to the similar results with wheat.

I. — Manure and Fertilizers furnishing Nitrogen compared. (Field A.)

A full description of the plan of the experiment on Field A was given in the twelfth annual report of the Hatch Experiment Station. There are two objects in view: first, to compare the efficiency (as measured by crop production) of a few of the standard materials that may be used on the farm as sources of nitrogen; second, to determine to what extent the introduction of a crop belonging to the clover family is capable of rendering the application of nitrogen to a succeeding crop of another family unnecessary. The materials furnishing nitrogen under comparison are barnyard manure, nitrate of soda, sulfate of ammonia, and dried blood. There are eleven plots in the field, and with few and practically unimportant exceptions each has been manured in the same way since 1899. All plots are liberally manured each year with materials supplying phosphoric acid and potash, and in quantities to furnish these elements in equal amounts. Manure or fertilizers supplying nitrogen are applied yearly to eight of the eleven plots, and in quantities to furnish nitrogen at the rate of 45 pounds per acre to each. Barnyard manure is applied to one plot, nitrate of soda to two, sulfate of ammonia to three, and dried blood to two plots. Three plots have had no nitrogen applied to them since 1884. The potash applied to these plots is supplied in the form of muriate to six plots, viz., 1, 3, 6, 7, 8 and 9. It is supplied in the form of low-grade sulfate to four plots, viz., 2, 4, 5 and 10. The crops grown in this experiment previous to this year in the order of their succession have been: oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover, potatoes, soy beans, potatoes. The crop of this year was the medium green soy bean.

It will be generally understood that, if the object in view in an experiment should be simply the determination of the relative value of different materials applied as sources of nitrogen, such a crop as the soy bean (which belongs to the clover family, and which therefore under the right conditions can draw upon the air for a portion or perhaps for all of its nitrogen) would not be selected; but we are testing not simply the relative value of the different nitrogen manures, but also the effect of the legume grown on the no-nitrogen plots upon the succeeding crop. Accordingly, the soy bean, which is one of the most successful of the legumes grown as a hoed crop, was our choice, as it has been several other years, during the progress of this experiment.

The crop was planted on May 20, and was well cared for throughout the season. No accident or inequality in extent of insect or other damage on the several plots interfered with the normal results of the experiment; but the season was highly unfavorable to the growth of the crop, which is one requiring protracted warm weather.

Although the yield on the plots to which the nitrate of soda was applied was fairly satisfactory, attention is here called to the fact that this fertilizer seems to exert an adverse influence upon the early development of the soy bean. It has been repeatedly noticed that where nitrate of soda is the source of nitrogen, the leaves, especially in the early stages of growth, assume a crinkled or wrinkled appearance, and fail to reach full size and normal development. This crinkling appears to be due to the death of the marginal tissues of the leaf, and such death is supposed to be due to an accumulation of nitrates in injurious amounts in these tissues. The margin of the leaf ceasing to grow, while its main body still continues to develop, the inevitable consequence is the crinkling effect which has been alluded to. As the season advances, the soy bean plants as a rule show a more normal leaf development; and, although the crinkling this season was excessive, the yield on the nitrate of soda plots does not appear to have been materially decreased, as a consequence.

Attention is here called, with regret, to the fact that there was undoubtedly an error made in determining the weight of the straw on Plot 10. Close observation throughout the season leads to the conclusion on the part both of my assistant and myself that the relative growth of vines as compared with seed on this plot was quite as large as on any other in the field, and yet the weight as reported shows it to have been in proportion to seed less than on any other plot.

The yields obtained on the several plots and the sources of nitrogen on each are shown in the following table: —

Yield of Soy Beans per Acre.

Plots.	Nitrogen Fertilizers used.	Beans (Bushels).	Straw (Pounds).
0, .	Barnyard manure (most of potash used contained in the manure).	23.8	2,010
1, .	Nitrate of soda (muriate of potash), ...	20.5	1,700
2, .	Nitrate of soda (sulfate of potash), ...	24.8	2,080
3, .	Dried blood (muriate of potash), ...	16.7	2,015
4, .	No nitrogen (sulfate of potash), ...	17.1	1,705
5, .	Sulfate of ammonia (sulfate of potash), ...	16.9	1,480
6, .	Sulfate of ammonia (muriate of potash), . . .	11.6	1,160
7, .	No nitrogen (muriate of potash), ...	11.1	1,125
8, .	Sulfate of ammonia (muriate of potash), . . .	14.8	1,390
9, .	No nitrogen (muriate of potash), ...	8.8	745
10, .	Dried blood (sulfate of potash), ...	21.7	1,225

It will be noticed that the crop, even on the best plot, this year is small. In 1901, when the same crop was grown, the yield on the poorest plot was at a higher rate (25.86 bushels of seed) than that on the best plot this year; while the average yield on all plots, including those to which no nitrogen was applied, was at the rate of 29.9 bushels per acre in 1901. The inferiority of the crop of this year was undoubtedly largely the consequence of the unfavorable season, although there is some evidence that this soil may once more need an application of lime. It has received no lime since 1898, when this material was applied at the rate of one ton to the acre. An abundance of lime in the soil is well known to be highly important to nearly all legumes.

The average yields of this year, as affected by the fertilizers used, are clearly shown in the following table: —

FERTILIZERS USED.	Beans (Bushels).	Straw (Pounds).
Average of the no-nitrogen plots (3),	12.3	1,192
Average of the nitrate of soda plots (2),	22.7	1,890
Average of the dried blood plots (2),	19.2	1,620
Average of the sulfate of ammonia plots (3),	14.4	1,343

As the result of all experiments previous to this year, it is found that the materials furnishing nitrogen have produced crops ranking in the following order: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	93.10
Sulfate of ammonia,	92.00
Dried blood,	90.80
No nitrogen,	73.80

Similar averages for this year are shown below: —

FERTILIZERS USED.	Beans (Per Cent.).	Straw (Per Cent.).
Barnyard manure,	100.00	100.00
Nitrate of soda,	95.38	94.03
Dried blood,	80.67	80.60
Sulfate of ammonia,	60.50	66.82
No nitrogen,	51.68	59.30

The nitrate of soda, as last year, stands relatively lower than it usually has done. It is believed that the excessive rains of the past two seasons have caused the loss of some of the nitrate of soda; which may well have washed through the soil and been carried away in the drainage waters.

The average yield of all the nitrogen plots, as compared with the average of those receiving no nitrogen, is shown below: —

	Beans (Bushels).	Straw (Pounds).
Average, 8 nitrogen plots,	18.85	1,633
Average, 3 no-nitrogen plots,	12.33	1,192

It will be noticed that the no-nitrogen plots give only about 65 per cent. as much seed as the plots receiving nitrogen, and about 73 per cent. as much straw. The nodules in which are found the bacteria connected with the assimilation of atmospheric nitrogen were very abundant upon the roots of the plants upon all plots, as was determined by frequent examination. In spite of this fact, the supply of nitrogen at the disposition of the plants on the no-nitrogen plots appears to have been inadequate for even fairly vigorous growth. No reason can be assigned, unless it be that the acid condition of the soil prevented the normal action of the agencies connected with the assimilation of atmospheric nitrogen.

In conclusion, attention is called to the fact that nitrate of soda must be regarded as one of the most desirable of the materials that can be purchased as a source of nitrogen. The cost of nitrogen in this form is lower than in most other materials, and in this as well as in other experiments upon our grounds it usually shows itself to be more effective than any other nitrogen fertilizer. Its superiority to the other materials used in this experiment is made more evident if in place of comparing total yields we compare the increases in yields produced by the several nitrogen fertilizers. On this basis, including all crops raised to date, but taking into account the seed only for this year, the different materials rank as follows: —

Relative Increases in Yields, Average for Fourteen Years.

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	77.80
Dried blood,	65.10
Sulfate of ammonia,	63.60

II. — The Relative Value of Muriate and High-grade Sulfate of Potash. (Field B.)

The experiments on this field are in continuation of work which has been in progress since 1892, and I cannot do better in introducing what is to be reported for this year than to quote from my last annual report. The object of this experiment "is to determine the relative value for different crops of the two leading and cheapest sources of potash, viz., muriate and high-grade sulfate. These salts are used in equal quantities continuously upon the same land. The field contains eleven plots, of approximately one-eighth of an acre each. Of these, six have been yearly manured with muriate of potash and five with the high-grade sulfate. From 1892 to 1899 inclusive these salts were used at the rate of 400 pounds per acre; since 1900 the rate of application has been 250 pounds per acre. Fine-ground bone at the rate of 600 pounds per acre has been yearly applied to all plots. Various crops have been grown in rotation, including potatoes, field corn, sweet corn, grasses, oats and vetch, barley and vetch, winter rye, clovers of various kinds, sugar beets, soy beans and cabbages. Most of these crops have been grown during several years. All have with few exceptions given uniformly large yields. The results to date may be summarized as follows: among the crops grown, the potatoes, clovers, cabbages and soy beans have usually done much the best on sulfate of potash; the yield of corn, grasses, oats, barley, vetches and sugar beets has been about equally good on the two salts; the quality of the potatoes and sugar beets produced on the sulfate of potash plots has been distinctly better than that of the crops produced on the muriate of potash."

The crops of the past year have been potatoes, cabbages, onions, and soy beans, while on two plots perennial garden crops and small fruits, viz., rhubarb, asparagus, raspberries and blackberries have been started. The crops both of onions and cabbages were practically failures; in both cases, it is believed, largely on account of the abnormally cold and otherwise very unfavorable season. The onion crop throughout this entire section was in general the poorest known for years. The cabbages made a healthy growth, but, as the season proved, were started much too late. With average summer temperatures the crop would have matured, but under the conditions of the past season few heads reached marketable development. The number of such heads on the muriate of potash was considerably more than on the sulfate, and the total weight of the crop on the muriate was at the rate of about 4,400 pounds per acre greater than on the sulfate. In the case of the onions the total weight of crop produced, including scallions and tops, was at the rate of about 1,000 pounds per acre greater on the muriate than on the sulfate, but there were only 5 bushels more of good onions. In view of the nature of the results with these two crops, further details concerning them will not be given.

1. *Soy Beans* (*Sulfate v. Muriate of Potash*).

The variety of soy beans grown in this experiment was the medium green. This crop occupied two plots (17 and 18), which last year produced a crop of cabbages. The yield of cabbages last year on the sulfate of potash was at the rate of about 5 tons to the acre more than on the muriate. The crop this year suffered from no accidental conditions affecting results, but owing to the unfavorable season the yields were very small. The results are shown in the table: —

Muriate v. High-grade Sulfate of Potash. — Medium Green Soy Beans, Yields per Acre.

FERTILIZERS USED.	Beans (Bushels).	Straw (Pounds).
Muriate of potash, ...	11.20	1,000
Sulfate of potash, ...	10.73	689

It will be noted that the yield of beans is slightly greater on the muriate than on the sulfate; the difference, however, is exceedingly small, and no especial significance can be attached to it. In previous years the sulfate of potash has usually given the better crop of this variety of beans, and I am still inclined to advise its selection. The greater depletion of the soil as a result of the heavy yield of cabbages last year on the plot receiving the sulfate of potash may in part account for the fact that the sulfate of potash this year fails to show its usual superiority.

2. *Potatoes (Sulfate v. Muriate of Potash).*

The potatoes in this experiment were of the Beauty of Hebron variety; the seed was grown in northern Maine. This crop occupied two plots (11 and 12), which last year produced a mixed crop of timothy and clover. The sod was broken this spring, and the seed, which had been previously treated with formalin for destruction of scab spores, and budded, was planted on May 16. An effort was made to protect the crop from insects and blight by the use of prepared insecticides and fungicides offered in our markets. These proved fairly satisfactory in the destruction of the potato beetle, but were not entirely effective in preventing blight. The vines began to show signs of blight on July 18, but its progress was slow; there was but very little rot, and the yield was fairly satisfactory. The potatoes were dug after the vines were entirely dead, and the yields were as shown below.

Muriate v. High-grade Sulfate of Potash. — Potatoes, Yield per Acre (Bushels).

FERTILIZERS USED.	Merchantable.	Small.
Muriate of potash, ...	171.71	29.94
Sulfate of potash, ...	194.58	29.09

It will be noticed that the yield of small tubers was practically identical on the two potash salts, but that the sulfate of potash gave a yield of merchantable tubers at the rate of nearly 23 bushels per acre greater than the muriate. This result is in exact agreement with the results of many other experiments which have been tried upon our grounds; and it seems to be impossible to doubt that sulfate of potash should be generally selected for the potato, rather than the muriate, for all soils which have a fair capacity to retain moisture.

Farmers raising the crop on such soils should demand potato fertilizers in which this salt has been used as the source of potash. Not only is the crop almost invariably larger on the sulfate, but it is of superior eating quality. Previous experiments here have shown that it almost invariably contains from 2 to 3 per cent. more starch, and that when cooked the potatoes are whiter, of better flavor, and more mealy.

III. — Fertilizers for Garden Crops. (Field C.)

The object in this experiment is to study the influence of a few standard fertilizers used continuously upon the same land upon the yield of garden crops. The experiments were begun in 1891, and from that date to 1897 inclusive fertilizers alone were applied to the land. During the past six years stable manure also has been applied in equal quantities (at the rate of 30 tons per acre) to each of the plots, while the fertilizers have been used in the same amounts and applied to the same plots as at first. The original number of plots in the experiment was six, of about one-eighth of an acre each. On all of these fertilizers were used. When we first began to apply manure as well as fertilizers, we introduced into the experiment a seventh plot of the same area as the others, but which had had different previous manurial treatment. To this we have since applied manure only at the above-named rate. This plot was introduced in order that we might have a basis for determining whether the materials used were in any degree beneficial when added to the somewhat liberal quantity of manure employed. It was found that at first the yields of almost all crops on the manure alone were almost as good as those where the fertilizers also were used. In a few cases the manure alone gave the better crops. It is not believed that we are justified in concluding that the fertilizers have been used without beneficial effect, for the no-fertilizer plot introduced in 1898 had, previous to that year, been more heavily manured than the other plots. The superiority of the plot receiving manure alone seems to be gradually decreasing, and this plot will doubtless ultimately serve as a basis for making fair comparisons between the results obtainable with manure alone and results obtained with equal manure and fertilizers. Up to the present time it is not considered to have furnished such a basis, and no reference accordingly will be made in this report to the yields upon this plot.

All the prominent out-door garden crops in this locality have been grown in rotation upon each plot, and each crop during several years. The list of crops so far grown includes spinach, lettuce, onions, garden peas, table beets, early and late cabbages, potatoes, tomatoes, squashes, cucumbers, turnips, sweet corn, celery, and one small fruit, — strawberries. Asparagus and rhubarb were set in 1902, but no cuttings have yet been made, and these will not therefore be referred to in this report.

As stated in my last annual report, these " experiments have been planned with reference to throwing light especially upon two points: *A.* The relative value of nitrate of soda, sulfate of ammonia and dried blood used as sources of nitrogen. *B.* The relative value of sulfate of potash and muriate of potash. These two points will be separately discussed."

A. — The Relative Value of Nitrate of Soda, Sulfate of Ammonia and Dried Blood as Sources of Nitrogen.

The three fertilizers compared as sources of nitrogen have from the first been applied in such amounts as to furnish equal nitrogen to each plot (at the rate of 60 pounds per acre), and each fertilizer is always applied to the same plot. An application supplying per acre the amount of nitrogen above named requires the annual application of materials at about the following rates per acre: —

	Pounds.
Nitrate of soda, ...	375
Sulfate of ammonia, ...	300
Dried blood, ...	850

Each of these nitrogen fertilizers is used on two plots, on one with sulfate of potash, on the other with muriate, — in both cases in such quantities as to furnish equal actual potash.

The results with some of the crops, especially where sulfate of ammonia is the source of nitrogen, have been widely different on these two potash salts, the yields on the sulfate being greatly superior to those on the muriate. The potash salts are applied in such quantities as to furnish potash at the rate of 120 pounds per acre, which requires the use of about 240 pounds of commercial muriate or high-grade sulfate of potash. Dissolved bone-black is used on all plots as the source of phosphoric acid, and in such quantity as to furnish phosphoric acid at the rate of about 50.4 pounds per acre. To furnish this, dissolved bone-black is applied at the rate of about 320 pounds per acre.

The results previous to this year may be summarized as in our last annual report. For the early crops, *i.e.*, the crops making most of their growth before mid-summer, including onions, lettuce, table beets, garden peas, spinach, early cabbages and strawberries, the nitrate of soda has been found the most effective source of nitrogen. The relative standing of the different nitrogen fertilizers, as measured by the total yields, including leaves, vines and tops as well as the marketable product, is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	93.70
Sulfate of ammonia,	57.30

For the late crops, including late cabbages, turnips, celery, tomatoes and squashes: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	99.00
Sulfate of ammonia,	78.40

The crops grown in this experiment this year for which results will be reported include strawberries, followed by celery; dandelions, followed by cucumbers; tomatoes; beets; and garden peas, followed by turnips. The weather conditions have been highly unfavorable to the normal growth and development of some of these crops, especially tomatoes, but a small proportion of which ripened, and cucumbers. The excessively dry weather of the month of May, followed by the equally excessively wet weather of the month of June, gave us conditions no doubt extremely unfavorable to the action of all the nitrogen fertilizers, but apparently particularly so in the case of the nitrate of soda. Moreover, considerable damage was done both to dandelions and strawberries through the burning of the leaves, caused by the application of the nitrate of soda and the sulfate of ammonia. The application of either of these chemicals as a top-dressing to a growing crop requires the utmost care. It was not the belief of the assistant applying the materials that these chemicals adhered to the leaves when applied in such quantity as to prove injurious; but the result proved that he was mistaken in his judgment, for the injury through burning of the leaves both of the dandelions and the strawberries where nitrate of soda and sulfate of ammonia were applied was very serious. Doubtless as a consequence chiefly of the conditions to which attention has been called, the dried blood, as compared with the other nitrogen fertilizers, ranks this year relatively higher than in any previous year.

The average rate of yield per acre obtained with each of the nitrogen fertilizers, used it will be remembered in addition to the manure, for the present season is shown in the following table: —

Nitrogen Fertilizers for Garden Crops. — Rate of Yield per Acre (Pounds), Average of Two Plots.

FERTILIZERS USED.	Dandelions.	Strawberries.	PEAS.		BEETS.	
			Pods, Green.	Vines, Green.	Roots.	Tops.
Sulfate of ammonia, .	37,857	5,010	11,210	9,758	37,866	43,507
Nitrate of soda, . . .	35,098	5,489	9,880	8,710	44,319	49,643
Dried blood, . . .	48,312	10,072	11,694	11,129	46,429	41,689

Nitrogen Fertilizers for Garden Crops, etc. — Concluded.

FERTILIZERS USED.	TOMATOES.			CUCUMBERS.		Celery.	TURNIPS.		
	Ripe.	Green.	Vines.	Fruit.	Vines.		Large.	Small.	Leaves.
Sulfate of ammonia.	8,613	26,891	18,293	2,772	5,979	16,870	33,442	12,662	29,221
Nitrate of soda,	8,293	24,726	16,768	4,701	8,016	34,553	44,351	7,598	33,442
Dried blood, .	8,171	23,842	12,805	2,718	4,076	24,797	48,701	3,896	27,923

The relative influence of the nitrogen fertilizers has differed widely for the different crops, as is evident on examination of the above tables, and each must therefore be separately discussed.

Dandelions. — This crop was started in the summer of 1902. The fertilizers this year were applied evenly on April 14. The leaves, as above stated, were badly burned whereever nitrate of soda or sulfate of ammonia was used. The crop was cut May 6, at which time it was judged that the leaves had reached their maximum development. The plants were in blossom, and of course somewhat beyond the stage at which the crop is commonly cut for market. On the basis of the yields obtained, the relative standing of the different nitrogen fertilizers was as follows: —

	Per Cent.
Dried blood,	100.00
Sulfate of ammonia,	78.36
Nitrate of soda,	72.66

There can be no doubt that, as a result of the burning effect alluded to, both the sulfate of ammonia and nitrate of soda actually decreased the yield.

Strawberries. — The vines from which the fruit harvested this year was picked were set in the spring of 1902. The fertilizers used were evenly spread broadcast on April 14. Within a few days the leaves began to show marked injury on the nitrate of soda and sulfate of ammonia plots. On the basis of total weights of ripe fruit, the nitrogen fertilizers ranked in the following order: —

	Per Cent.
Dried blood,	100.00
Nitrate of soda,	54.50
Sulfate of ammonia,	49.74

Without doubt both the nitrate of soda and the sulfate of ammonia proved actually injurious.

Garden Peas. — The fertilizers applied to this crop were spread broadcast after plowing on April 30, and harrowed in. On the basis of weights of pods and vines harvested, the nitrogen fertilizers take the following relative rank: —

FERTILIZERS USED.	Pods (Per Cent.).	Vines (Per Cent.).
Dried blood,	100.00	100.00
Sulfate of ammonia,	95.86	87.68
Nitrate of soda,	84.55	78.26

The yields on the sulfate of ammonia were slightly greater than where no fertilizer was added to the manure. On the nitrate of soda they were considerably less, and there is no evidence that the latter benefited the crop.

Table Beets. — The fertilizers for this crop were applied at the same time and in the same manner as for the peas. As indicated by the yields, the relative standing of the different nitrogen fertilizers for this crop is as follows: —

FERTILIZERS USED.	Beets (Per Cent.).	Tops (Per Cent.).
Dried blood,	100.00	83.97
Nitrate of soda,	95.47	100.00
Sulfate of ammonia,	83.50	87.62

The fertilizers were apparently moderately beneficial to this crop, but the nitrate of soda stands relatively much lower than in previous years.

Tomatoes. — Fertilizers were applied as in the case of garden peas. The relative standing of the nitrogen fertilizers, as indicated by the yields (ripe and green fruit and vines), is as follows: —

FERTILIZERS USED.	Ripe Fruit (Per Cent.).	Green Fruit (Per Cent.).	Tops (Per Cent.).
Sulfate of ammonia,	100.00	100.00	100.00
Nitrate of soda,	96.28	91.97	91.67
Dried blood,	94.86	88.66	70.00

Cucumbers. — The cucumbers were planted on June 30, being put in to replace squashes, which had been killed by too heavy an application of kerosene emulsion. The relative standing of the nitrogen fertilizers, as indicated by the weights of the fruit and vines, is as follows: —

Fertilizers used.	Fruit (Per Cent.).	Vines (Per Cent.).
Nitrate of soda,	100.00	100.00
Sulfate of ammonia,	58.96	74.53
Dried blood,	57.80	50.81

The vines in this experiment were somewhat affected by fungi, which doubtless influenced both yield of fruit and growth. The nitrate appears to have exerted a very favorable influence, but the reasons, in view of the character of the season and the lateness of the crop of cucumbers, are not evident. Both the amount of fruit, however, and the weight of the vines produced where the nitrate was used were materially greater than where no fertilizers were employed.

Celery. — This crop followed the fruiting strawberries, and the manure applied this year to these plots was turned in with the strawberry vines. The fertilizers called for on the several plots had been applied in the spring as a top-dressing to the strawberries. The relative standing of the different nitrogen fertilizers, as indicated by the total weight of the crop when dug in the fall and the roots freed from earth, is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	71.76
Sulfate of ammonia,	48.94

Turnips. — This crop was sown on July 30, following garden peas. The variety was the White Egg. The relative standing of the nitrogen fertilizers, as indicated by the weights of roots of the different qualities and leaves, is as follows: —

Fertilizers used.	Merchantable (Per Cent.).	Culls (Per Cent.).	Leaves (Per Cent.).
Dried blood,	100.00	30.61	83.33
Nitrate of soda,	91.20	60.20	100.00
Sulfate of ammonia,	68.80	100.00	87.21

The relative standing of the different nitrogen fertilizers for the early crops of this year, including dandelions, strawberries, peas and beets, as indicated by the combined weights of merchantable products, tops and vines, is: —

	Per Cent.
Dried blood,	100.00
Nitrate of soda,	83.13
Sulfate of ammonia,	82.67

For the late crops, including tomatoes, cucumbers, celery, cabbages and turnips, the relative standing determined in the same manner is: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	95.20
Sulfate of ammonia,	85.74

Combining the results of 1903 with the twelve previous years, the relative standing of the nitrogen fertilizers is: —

	Per Cent.
For the early crops: —	
Nitrate of soda,	100.00
Dried blood,	95.42
Sulfate of ammonia,	60.03
For the late crops: —	
Nitrate of soda,	100.00
Dried blood,	98.76
Sulfate of ammonia,	78.96

B. — The Relative Value of Sulfate and Muriate of Potash for Garden Crops.

The general conditions under which these experiments have been tried have been already outlined. It will be remembered that these salts are under trial in connection with the sulfate of ammonia, nitrate of soda and dried blood as sources of nitrogen when used in addition to manure for garden crops. The crops grown on these two potash salts, therefore, are the same as those which have been named in discussing the relative value of the different nitrogen fertilizers. Each potash salt is used on three plots, *i.e.*, with each of the three nitrogen fertilizers. The results for the past year are shown by the following table: —

Sulfate and Muriate of Potash compared as Fertilizers for Garden Crops. — Yield per Acre (Pounds), Average of Three Plots.

FERTILIZERS USED.	Dandelions.	Strawberries.	PEAS.		BEETS.	
			Pods, Green.	Vines, Green.	Roots.	Tops.
Muriate of potash, ...	41,385	6,531	11,586	9,570	44,502	45,541
High-grade sulfate of potash, . .	39,459	7,183	10,269	10,162	41,840	44,351

Sulfate and Muriate of Potash compared, etc. — Concluded.

FERTILIZERS USED.	TOMATOES.			CUCUMBERS.		Celery.	TURNIPS.		
	Ripe.	Green.	Vines.	Fruit.	Vines.		Large.	Small.	Leaves.
Muriate of potash.	8,069	24,797	14,431	2,699	4,982	24,119	42,208	7,143	28,918
High-grade sulfate of potash.	8,648	25,508	17,480	4,094	7,065	26,694	42,121	8,961	31,472

Examination of the table reveals the fact that the results for this season are the precise opposite of the results which have been obtained in most of our previous experiments. The muriate of potash gives the greater yield in the case of all the early crops, and the sulfate of potash the larger yield in the case of all the late crops. It is well understood that muriate of potash dissolves and diffuses through the soil somewhat more readily than sulfate, and, further, that it makes soils more retentive of moisture; and it may be that the great deficiency in rainfall which prevailed during the season until early in June left the soil so dry that the sulfate of potash did not become sufficiently dissolved and diffused to become available to the early crops.

The relative average standing of these two salts, as indicated by the total yields of all crops grown previous to this year, is shown in the following table: —

FERTILIZERS USED.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Sulfate of potash, ...	100.00	100.00
Muriate of potash, ...	93.20	102.90

The relative average standing for this year, determined upon the same basis, is as follows : —

FERTILIZERS USED.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Muriate of potash,	100.00	92.66
Sulfate of potash,	98.36	100.00

Combining these results with those of the twelve previous years, the average standing, as indicated by total yields, is as shown in the following table : —

FERTILIZERS USED.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Sulfate of potash,	100.00	97.97
Muriate of potash,	93.84	100.00

The total rainfall during the past season from April 17, the date when the fertilizers were applied to the dandelions and strawberries, to June 7 was .48 inches. Such a rainfall must have been quite insufficient to bring the less soluble fertilizers into circulation, and the failure of the sulfate of potash to produce its usual effect on the early crops is not surprising. It has been repeatedly noticed in experiments here that in excessively dry seasons the muriate of potash usually excels the sulfate for all crops, even those which ordinarily do better on the sulfate. Following this period of excessive drouth came a period extending from the 7th of June to the end of the month with equally excessive rainfall, the total precipitation for that period amounting to 7.79 inches. July was also a comparatively rainy month, and it seems probable that the more soluble muriate of potash may have been largely carried into the subsoil. In this position it would not be equally available to the late crops as the less soluble sulfate.

It is not the belief of the writer that the fact that the relation of the two potash salts for this season to early and late crops respectively is exactly the reverse of what it has been in previous years, should lead to a modification of the advice which has been previously given, viz., that the sulfate should generally be preferred for the early crops and the muriate for the late on all soils with a fair capacity to retain moisture.

IV. — COMPARISON OF DIFFERENT POTASH SALTS FOR FIELD CROPS. (FIELD G.)

The experiment for comparison of different potash salts was begun in 1898. The field contains forty plots, of about one-fortieth of an acre each. The plots are fertilized in five series of eight plots each, each series including a no-potash plot and one plot for each of the potash salts under comparison. Those salts are kainite, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and silicate. Each is applied annually to the same plot, and all are used in such amounts as to furnish equal potash to each plot. In the quantities employed the different salts supply annually actual potash at the rate of 165 pounds per acre. All plots are equally manured with materials furnishing fairly liberal amounts of nitrogen and phosphoric acid. The crop of the past season was mixed clover and timothy. This is the second year that this crop has occupied the land. The table which follows, showing yields, does not quite accurately show the effect of the fertilizers. It was out of the question to separate weeds and grasses from the clover in an experiment conducted on the scale of this. Most careful examination often repeated during the season made the following points self-evident: —

1. That on the no-potash plots the clover was very thin, but the weeds of various kinds were relatively abundant.

2. That on the plots to which kainite was applied the clover was weaker than on any of the other plots receiving potash. The timothy, on the other hand, was more abundant and apparently more vigorous on the kainite plots than on the others.

3. On the muriate of potash plots the clover was inferior to all other plots receiving potash except the kainite, and here also timothy was relatively abundant and vigorous.

4. The clover on the low-grade sulfate of potash plots was distinctly inferior to that on the high-grade sulfate.

The fact that the differences above noted were repeated with little variation in each of the series of plots leaves no room to doubt the highly unfavorable influence on the development of the clover of the kainite and the muriate, and the moderately unfavorable effect of the low-grade sulfate.

The field was cut twice, the hay carefully cured, to a considerable extent in cocks, and without much loss of leaf or head. The table shows the rates of yield per acre for both first and second cut, as well as the total for each plot: —

Clover. — Yield per Acre (Pounds).

Plots.	POTASH SALT.	Hay.	Rowen.	Total.
1, . . .	No potash, ...	3,462	1,653	5,115
2, . . .	Kainite, ...	3,462	3,592	7,054
3, . . .	High-grade sulfate, ...	3,307	1,586	4,893
4, . . .	Low-grade sulfate, ...	3,150	2,100	5,250
5, . . .	Muriate, ...	3,441	2,368	5,809
6, . . .	Nitrate, ...	2,927	2,234	5,161
7, . . .	Carbonate, ...	2,882	2,011	4,893
8, . . .	Silicate, ...	3,128	2,279	5,407
9, . . .	No potash, ...	3,239	1,698	4,937
10, . . .	Kainite, ...	4,424	2,435	6,859
11, . . .	High-grade sulfate, ...	4,021	2,011	6,032
12, . . .	Low-grade sulfate, ...	3,977	1,921	5,898
13, . . .	Muriate, ...	3,753	2,055	5,808
14, . . .	Nitrate, ...	3,977	2,100	6,077
15, . . .	Carbonate, ...	3,462	2,011	5,473
16, . . .	Silicate, ...	4,155	1,988	6,143
17, . . .	No potash, ...	3,753	1,720	5,473
18, . . .	Kainite, ...	4,357	1,698	6,055
19, . . .	High-grade sulfate, ...	4,066	1,698	5,764
20, . . .	Low-grade sulfate, ...	4,200	2,190	6,390
21, . . .	Muriate, ...	4,379	2,145	6,524
22, . . .	Nitrate, ...	3,843	1,899	5,742
23, . . .	Carbonate, ...	4,021	1,609	5,630
24, . . .	Silicate, ...	3,999	1,966	5,965
25, . . .	No potash, ...	2,458	1,609	4,067
26, . . .	Kainite, ...	4,021	2,122	6,143
27, . . .	High-grade sulfate, ...	3,753	1,519	5,272
28, . . .	Low-grade sulfate, ...	4,446	1,966	6,412

Clover. — Yield per Acre (Pounds) — Concluded.

Plots.	Potash Salt.	Hay.	Rowen.	Total.
29,	Muriate,	3,820	1,765	5,585
30,	Nitrate,	3,664	1,430	5,094
31,	Carbonate,	3,664	1,452	5,116
32,	Silicate,	4,021	1,787	5,808
33,	No potash,	3,619	1,519	5,138
34,	Kainite,	4,088	1,921	6,009
35,	High-grade sulfate,	3,709	1,631	5,340
36,	Low-grade sulfate,	4,111	1,564	5,675
37,	Muriate,	3,932	1,832	5,764
38,	Nitrate,	3,441	1,698	5,139
39,	Carbonate,	3,753	1,810	5,563
40,	Silicate,	3,887	1,787	5,674

The influence of the different potash salts is somewhat more clearly brought out by the table below, which gives the average results for each of the potash salts employed: —

Clover. — Average Yield per Acre (Pounds).

Potash Salt.	Hay.	Rowen.	Total.
No potash (plots 1, 9, 17, 25, 33),	2,066	1,025	3,091
Kainite (plots 2, 10, 18, 26, 34),	2,544	1,471	4,015
High-grade sulfate (plots, 3, 11, 19, 27, 35),	2,357	1,056	3,413
Low-grade sulfate (plots 4, 12, 20, 28, 36),	2,485	1,218	3,703
Muriate (plots 5, 13, 21, 29, 37),	2,416	1,271	3,687
Nitrate (plots 6, 14, 22, 30, 38),	2,232	1,170	3,402
Carbonate (plots 7, 15, 23, 31, 39),	2,223	1,112	3,335
Silicate (plots 8, 16, 24, 32, 40),	2,399	1,226	3,625

The average yield on the plot receiving no potash is much lower than on the other plots, in spite of the fact that weeds helped to a considerable extent to make up the deficiency in clover and timothy. The kainite gives the highest total yield of hay. This was doubtless in part due to the fact that the large mixture of timothy enabled the crop to stand up better during the heavy rains of the month of June than on those plots where the clover so largely predominated. The plots receiving high-grade sulfate of potash lodged very badly, — more seriously than any other plots in the field; and, as bad weather necessitated cutting the crop somewhat late, the vigor of the plants was undoubtedly lowered, as shown by the relatively low yield of rowen on these plots. They without doubt exhibited the highest average development of clover during the early part of the season, and with a more normal season should have given the heaviest rowen.

What is true of the high-grade sulfate of potash plots is doubtless also true in somewhat lesser degree of the plots manured with the silicate, carbonate and nitrate.

The experiment of this year lends additional support to the advice which has previously been given, viz., that "on soils with good retentive qualities sulfate of potash should generally be preferred to muriate or kainite for clovers," in spite of the fact that the total yields, including timothy, are heavier on these plots.

V. — COMPARISON OF PHOSPHATES ON THE BASIS OF EQUAL APPLICATION OF PHOSPHORIC ACID.

In this experiment, which has now been in progress seven years, we are endeavoring to determine by means of the growing crops the relative availability of a number of different phosphates. Those under comparison are as follows: apatite, South Carolina rock phosphate, Florida soft phosphate, phosphatic slag, Tennessee phosphate, dissolved boneblack, raw bone, dissolved bone, steamed bone, and acid phosphate.

All phosphates under comparison are used in amounts sufficient to furnish actual phosphoric acid at the rate of 96 pounds per acre, and each is applied annually in finely ground form to the same plot. The field contains thirteen plots, of about one-eighth of an acre each. Three of these plots have received no application of phosphoric acid since the beginning of the experiment. One of these is at either end, and the other in the middle, of the field. All plots are supplied alike with materials furnishing nitrogen and potash in available forms in liberal amount and in equal quantities to each. The materials used as sources of nitrogen and potash furnish nitrogen at the rate of 52 pounds and potash at the rate of 152 pounds per acre. With some crops a supplementary application of a quick-acting nitrogen fertilizer has been made to all plots alike. The crops which have been grown in this field during the progress of the experiment are as follows: corn, cabbages, corn, in 1900 two crops, — oats and Hungarian grass (both for hay), onions, and onions. With the exception of the onions, all the crops previously grown in this field have given good yields, even on the three plots in the field which have received no phosphate.

The soil of the field at the beginning of the experiment was not quite even in quality throughout. Plot 1 surpassed any other in the field in fertility at the start, and on the whole (although the difference is not very marked) there appears to be a gradual natural decline in productiveness from this end of the field toward the other.

The crop of the present season was cabbages. The variety is the Danish Ball-head. The seed was sown at the usual time for the crop in this locality, but so abnormally cold was the season that the crop was far from mature when cold weather set in. Still, the yields (which include weight of stumps, loose leaves and soft heads, as well as the weight of hard heads and totals) make it possible to estimate the relative availability of the different phosphates to the crop grown. The rates of yield per acre are shown in the following table: —

Cabbages on Plots with Equal Amounts of Phosphoric Acid.

Plots.	FERTILIZERS USED.	Number of Hard Heads.	Hard Heads (Pounds).	Soft Heads, Leaves and Stumps (Pounds).	Total Crop (Pounds).
1,	No phosphate,	1,184	4,040	9,360	13,400
2,	Apatite,	776	3,560	17,360	20,920
3,	South Carolina rock phosphate,	2,928	12,040	24,480	36,520
4,	Florida soft phosphate,	816	3,840	21,840	25,680
5,	Phosphatic slag,	2,232	9,920	28,040	37,960
6,	Tennessee phosphate,	440	1,720	29,160	30,880
7,	No phosphate,	104	400	14,120	14,520
8,	Dissolved bone-black,	2,336	8,392	31,520	39,912
9,	Raw bone,	2,304	11,800	32,440	44,240
10,	Dissolved bone meal,	2,384	12,760	29,320	42,080
11,	Steamed bone meal,	1,632	8,720	28,200	36,920
12,	Acid phosphate,	1,296	6,200	24,120	30,320
13,	No phosphate,	120	440	8,080	8,520

The most important points to which it seems desirable to call attention are the following: —

1. The no-phosphate plots give very low yields both of hard heads and total, indicating the marked dependence of the cabbage upon the supply of phosphoric acid.

2. Apatite and soft Florida phosphate are the least effective among the phosphates employed.

3. South Carolina rock gives a surprisingly good return, being exceeded in yield of hard heads by only one plot, — the one receiving dissolved bone, — while in total yield it is materially exceeded by but few.

4. The phosphatic slag ranks among the best of the phosphates used. It is exceeded in yield of hard heads by the dissolved bone-black, the South Carolina rock and the raw bone, in the order named; while in total weight of crop it is exceeded by the dissolved bone, the raw bone and the dissolved bone-black.

5. The most valuable crop in the field is that produced by the dissolved bone, although it is slightly exceeded in total yield by the crop on the raw bone.

6. Particular attention is called to the fact that this year, as in preceding years, the raw bone meal gives a crop much superior to that obtained by the use of steamed bone meal.

The differences in the development of the cabbages on the different plots in the field, as affected by the phosphates applied, became manifest at a very early date. The plants were scarcely a week old before marked differences could be seen; and the relative development throughout the season, as recorded after several examinations, was in about the order indicated by the final yields, although most observers ranked the crop on the phosphatic slag while growing relatively higher than indicated by the final result.

In estimating the significance of the results upon this field, it is important to keep in mind the facts as regards the character of the soil. It is what would be called a strong and moderately heavy loam, and has great capacity to retain moisture. The relatively insoluble phosphates are known to give better results on soils of this character than on those which are lighter and drier.

Our experiments indicate that the cabbage is one of those crops most closely dependent upon the supply of available phosphoric acid, and yet this crop gives us a good return upon phosphates ordinarily regarded as very slowly available. The opinion in general held concerning the necessity for acidulated phosphates may need modification. We have not, it is true, raised on the South Carolina rock or the raw bone crops of the highest rank, as measured by the number and weight of hard heads. The total yields are excellent, and the weights of hard heads in a more normal season would without doubt have been much higher. It appears reasonable to believe that on soils of the character of this field the farmer may safely depend for a considerable portion at least of the phosphoric acid needed by his crops upon the cheaper natural phosphates, such as finely ground South Carolina rock and finely ground bone, while phosphatic slag also promises to prove a most useful fertilizer upon soil of this character.

VI. — Soil Tests.

Two soil tests, both upon our own grounds and both in continuation of previous work upon the same fields, have been carried out during the past season. Fertilizers have been applied in accordance with the co-operative plan for soil tests, with one or two small exceptions. Lime and plaster have been applied to the plots calling for these fertilizers in double the usual soil test amounts. Each plot annually receives an application of the same kind or kinds of fertilizers. Such experiments are not adapted to securing the production of heavy crops, but rather to throwing light upon the general question as to the particular plant food requirements of different crops. By study of the results, the effects of the different leading elements of plant food on the several crops can be determined with much accuracy.

Every fertilizer used, whether applied by itself or in connection with one or both of the other fertilizer materials, is always applied in the same quantities. Both fertilizers and manure (where the latter is introduced for purposes of comparison) are always applied broadcast after plowing, and harrowed in. The kinds and the amounts per acre are as follows: —

Nitrate of soda, 160 pounds, furnishing nitrogen.
Dissolved bone-black, 320 pounds, furnishing phosphoric acid.
Muriate of potash, 160 pounds, furnishing potash.
Land plaster, 400 pounds.
Lime, 400 pounds.
Manure, 5 cords.

A. — Soil Test with Corn (South Acre).

This acre has been used in soil tests for fifteen years, beginning in 1889. The crops in successive years have been as follows: corn, corn, oats, grass and clover, grass and clover, corn (followed by mustard as a catch crop), rye, soy beans, white mustard, corn, corn, grass and clover, grass and clover, corn, and corn. Since 1889 this field has therefore borne seven corn crops, and during this time it has been four years in grass. The crop last year was corn, following grass; this year, corn follows corn. The season was the most unfavorable for this crop which has been known within the lifetime of most men now living, and the crop of this year was exceedingly poor, even on the land which has for fifteen years received an annual application of manure at the rate of 5 cords per acre. Last year, although the season then also was somewhat unfavorable, this plot gave a yield almost double that of this year. It is not surprising, therefore, that the yield on most of the plots receiving fertilizers was very low. Four of the plots have received neither manure nor fertilizer throughout the entire fifteen years, and these now show a degree of exhaustion amounting to almost absolute sterility. Allowing 90 pounds of ears as husked to the bushel of shelled grain, the average product of these plots was at the rate of about 1½ bushels to the acre. The average yield of stover on these plots is at the rate of 560 pounds per acre. The table shows the manuring of the several plots, the rate of yield, and the gain or loss per acre compared with the nothing plots: —

Corn. — South Acre Soil Test, 1903.

Plots.	Fertilizers used.	Yield per Acre.		Gain or Loss per Acre, compared with Nothing Plots.	
		Corn (Bushels, 90 Pounds).	Stover (Pounds).	Corn (Bushels 90 Pounds).	Stover (Pounds).
1, .	Nitrate of soda, ...	.56	360	—.44	—390
2, .	Dissolved bone-black, . .	.94	360	—.06	—390
3, .	Nothing, ...	.94	300	-	-
4, .	Muriate of potash, . . .	16.61	1,880	15.61	1,130
5, .	Lime, ...	.15	160	—.85	—590
6, .	Nothing, ...	1.06	1,200	-	-
7, .	Manure, ...	37.39	3,600	36.39	2,850
8, .	Nitrate of soda and dissolved bone-black.	3.89	800	2.36	430
9, .	Nothing, ...	1.28	340	-	-
10, .	Nitrate of soda and muriate of potash.	18.00	2,200	16.47	1,830
11, .	Dissolved bone-black and muriate of potash.	20.39	2,320	18.86	1,950
12, .	Nothing, ...	1.78	400	-	-
13, .	Plaster, ...	2.06	400	.53	30
14, .	Nitrate of soda, dissolved bone-black and muriate of potash.	25.56	3,040	24.03	2,670

In view of the highly unfavorable season, the development of the corn was far from normal, and extended discussion of the results does not seem called for. It will be noticed that, as in previous years, the potash among the fertilizer elements used is the one exercising by far the greatest effect in increasing the crop. The addition of either nitrate of soda or phosphoric acid, as shown by the results on plots 10 and 11, does not very materially increase the yield produced on potash alone (Plot 4). The addition of nitrate of soda to the mixture of potash and dissolved bone-black used on Plot 11 caused a considerable increase, — greater this year than in previous years, as shown by the yield on Plot 14. This difference in effect may very well be due to the gradual exhaustion of the supply of humus in the soil on these plots, which for so many years have been manured with fertilizers alone, and subjected to tillage throughout most of the time.

Though no combination of fertilizers gives what can be considered a good crop, the lesson is just as clear this year as in previous years, viz., that fertilizers for corn should be rich in potash.

B. — Soil Test with Mixed Grass and Clover (*North Acre*).

The field on which this test was carried out has been used in similar tests with various crops for fourteen years, beginning in 1890. The fertilizers have been applied in accordance with the system regularly used in soil tests, save as regards amounts. During the years when potatoes or onions have been grown, double the usual quantities have been employed. One other peculiarity in treatment must be reported. In the spring of 1899 one-half of each plot received an application of freshly slaked lime, at the rate of 1 ton per acre. This lime was spread after plowing, and worked in with a harrow. The crops in order of succession have been: potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and ruta-baga turnips, potatoes, onions for four years (1898 to 1901 inclusive), potatoes, and grass and clover. The crop upon which we are reporting followed potatoes. The seeds sown included the following varieties: timothy, red-top, and mammoth red and alsike clover. The seeds of the timothy (18 pounds), red-top (8 pounds), red clover (5 pounds) and alsike clover (4 pounds) were mixed and sown broadcast Sept. 15, 1902. The date of sowing was so late that the grass made relatively little growth during the autumn months and the clover winter-killed. The winter was, however, favorable for the grasses, and they came through without injury, and 15 pounds of red clover seeds were sown on April 4.

As has been pointed out in another connection, there was less than one-half inch of rain from the middle of April to the 7th of June. The conditions, therefore, were most unfavorable for the germination of the clover and for the growth of the young and therefore very shallow-rooted grass plants. The yields, therefore, were small, but the results are nevertheless of considerable interest. The fertilizers applied to the several plots and the rate of yield per acre with the gain or loss where the different fertilizers were employed are shown in the following table: —

Grass and Clover. — North Acre Soil Test, 1903.

Plots.	FERTILIZERS USED.	YIELD PER ACRE.		GAIN OR LOSS PER ACRE, COMPARED WITH NOTHING PLOTS.	
		Unlimed (Pounds).	Limed (Pounds).	Unlimed (Pounds).	Limed (Pounds).
1, .	Nothing, ...	360	1,150	-	-
2, .	Nitrate of soda, ...	1,520	3,140	1,096.7	2,036.7
3, .	Dissolved bone-black, . .	950	1,560	463.3	503.3
4, .	Nothing, ...	550	1,010	-	-
5, .	Muriate of potash, . . .	660	950	135.0	50.0
6, .	Nitrate of soda and dissolved bone-black.	1,830	3,180	1,330.0	2,390.0
7, .	Nitrate of soda and muriate of potash.	1,820	2,190	1,345.0	1,510.0
8, .	Nothing, ...	450	570	-	-
9, .	Dissolved bone-black and muriate of potash.	620	920	177.5	207.5
10, .	Nitrate of soda, dissolved bone-black and muriate of potash.	2,330	2,830	1,895.0	1,975.0
11, .	Plaster, ...	430	480	2.5	—517.5
12, .	Nothing, ...	420	1,140	-	-

Examination of the table makes the fact evident that it is the nitrate of soda chiefly which determined the rate of yield. It is further evident that this is able to exert its full influence only on the half of the plot which received the application of lime that has been referred to. Nitrate of soda alone on the limed half of the plot after fourteen years continuous use still gives a crop of hay at the rate of rather over 1½ tons per acre; used with dissolved bone-black, it gives almost exactly the same yield; used with muriate of potash, it gives a smaller yield, — only a little over 1 ton to the acre.

Much evidence is afforded, by a study of the relative proportions of the different species on the different plots and on the limed and unlimed portions of the several plots, that the soil in some parts of this field is once more becoming acid. It is likely that this is the case on Plot 7, for to that plot have been applied large quantities both of muriate of potash and nitrate of soda, both of which tend to aggravate the conditions leading to development of a sour condition of the soil. To Plot 10 dissolved bone-black has been added, as well as the nitrate of soda and muriate of potash, and this, because of the lime it contains, has helped to lessen the tendency to the development of acidity; but even on this plot the yield is less than on the nitrate of soda alone, and probably because of the acid condition induced by the continued use of the fertilizers the plot has received.

A careful determination of the relative proportions of the timothy, red-top and clover in the product of a square yard on both the unlimed and limed portions was made. On the unlimed portion of every plot the red-top was more abundant than the timothy. There was practically no clover on the unlimed portion of any plot. Timothy exceeded red-top on the limed portion of all plots except Plot 7. This is the plot to which both the nitrate of soda and muriate of potash have been applied; and here, in spite of the lime which was put on in 1899, the soil is undoubtedly again acid, as shown by the fact that the red-top exceeds the timothy. Clover was found in appreciable quantities only on the limed portion of plots 9 and 10. The lessons of the experiment, it seems to me, are clear, the following being the most important points: —

1. Nitrate of soda, as in many previous experiments, proves the controlling element in the production of grass; but this exerts the full effect of which it is capable only on soils which are not excessively acid.

2. Whenever, in a mowing seeded with a mixture of timothy and red-top, the latter largely predominates, it is an evidence that the productivity of the field would be increased by an application of lime.

3. Clover cannot be made to thrive in a soil unless it is free from acidity; and in those cases where on seeding clover fails, acidity may reasonably be looked for.

VII. — EXPERIMENT IN MANURING GRASS LANDS.

In this experiment, which has continued since 1893, the purpose is to test a system of using manures in rotation for the production of grass. The area used in the experiment is about nine acres. It is divided into three approximately even plots. The plan is to apply to each plot one year barnyard manure, the next year wood ashes, and the third year fine-ground bone and muriate of potash. As we have three plots, the system of manuring has been so arranged that every year we have a plot illustrating the results of each of the applications under trial. The rates at which the several manures are employed are as follows: barnyard manure, 8 tons; wood ashes, 1 ton; ground bone, 600 pounds, and muriate of potash, 200 pounds, per acre. The manure is always applied in the fall, ashes and the bone and potash in early spring. A portion of the land was broken up as described in the annual report for last year, on account of having become somewhat infested with weeds, and reseeded. That portion which was plowed after the removal of the first crop in the summer of 1902, repeatedly harrowed, and then seeded on August 15, has this year produced a very heavy crop. This, no doubt, may be in part attributed to the very thorough preparation which the land received before seeding, although the liberal manuring which it has received for so many years was no doubt also a most important factor. The past season, although it promised at the start, on account of the excessively dry weather from the middle of April to about the 10th of June, to be a very poor one for the hay crop, eventually proved decidedly favorable, as the frequent rains during the last three weeks in June produced a heavy growth. Conditions for the rowen crop were also exceptionally favorable. The yields of hay and of rowen and the totals for each system of manuring were at the following rates per acre: —

FERTILIZERS USED.	Hay (Pounds).	Rowen (Pounds).	Totals (Pounds).
Barnyard manure,	5,886	2,664	8,550
Bone and potash,	4,648	3,333	7,981
Wood ashes,	5,188	2,591	7 779

The average total yield of the entire area for this year is 8,104 pounds. The average for the entire period (1893 to the beginning of the present year) was 6,413 pounds. The average to date is 6,597 pounds. The average yield when top-dressed with manure has been 6,827 pounds; when top-dressed with wood ashes, 6,427 pounds; when top-dressed with bone and potash, 6,562 pounds. The average yields for this year, as will be seen, are much above the general average to date.

Old and New Seeding compared.

As has been stated, the yield on the part of the land reseeded last summer was very exceptionally heavy. The advantage of reseeding is made evident by comparison of the yields on that portion of plots 1 and 2 not reseeded with the yield on the portion which was reseeded. These comparisons are shown by the following table: —

	YIELD PER ACRE (POUNDS).		
	Hay.	Rowen.	Totals.
Plot 1, wood ashes: —			
Not reseeded,	4,305.0	1,938.0	6,243.0
Reseeded portion,	5,629.5	2,917.0	8,546.5
Plot 2, barnyard manure: —			
Not reseeded,	3,966.0	1,676.0	5,642.0
Reseeded portion,	6,845.5	3,157.5	10,003.0

The yields obtained on the reseeded portion, amounting to rather over 4¼ tons on one plot and to almost exactly 5 tons on the other, are certainly exceedingly satisfactory.

The Seed sown.

An effort is being made to render the results of the experiments on this land more valuable by comparing two different mixtures of grass seeds. As the result of experience, it has been found that on this land, under the system of manuring followed, timothy, and to a lesser degree red-top, tend to die out, and are replaced to a considerable extent by Kentucky blue-grass, — a species far less valuable for mowings. Tall and meadow fescue will, it is believed, prove more persistent, and it is hoped they may be able to hold the ground against the Kentucky blue-grass. With a view to testing these species as regards this point, equal areas of the reseeded portions of plots 1 and 2 have been sown with each of the two mixtures shown below: —

Fescue Mixture (Pounds per Acre).

Timothy,	6
Red-top,	8
Red clover,	5
Alsike clover,	4
Kentucky blue-grass,	4
Meadow fescue,	6
Tall fescue,	4

Timothy Mixture (Pounds per Acre).

Timothy,	18
Red-top,	8
Red clover,	5
Alsike clover,	4

These mixtures may be for convenience called respectively fescue mixture and timothy mixture. The relative yields in the first year on the two different seed mixtures is shown below: —

	Hay (Pounds).	Rowen (Pounds).	Totals (Pounds).
Plot 1: —			
Fescue mixture,	5,042	2,648	7,690
Timothy mixture,	6,217	3,186	9,403
Plot 2: —			
Fescue mixture,	6,521	2,921	9,483
Timothy mixture,	7,129	3,394	10,523

It will be seen that the timothy mixture has given the larger crops this year on both plots, both at the first and second cuttings. During the past dozen years many mixtures of grass seeds have been tried on different parts of the college estate, but none has been found which, everything considered, exceeds in value a mixture substantially that which is so generally used of timothy, red-top and clover. This mixture in the first year is clearly superior to the other, but whether it will maintain its superiority cannot of course be determined at present.

VIII. — Experiment in the Application of Manure.

The experiment upon which the results for the past year are to be reported was begun in 1899. The object in view is to determine whether it is better to spread fresh manure during late fall and winter, allowing it to remain upon the surface until spring, or to put the manure when hauled out into large heaps, to be spread just before plowing the land in the spring. A full account of the plan of this experiment will be found in the thirteenth annual report of this experiment station. The field contains five plots, each subdivided into two sub-plots, on one of which the manure is spread when hauled out during the winter and on the other put into a large heap from which it is hauled out and spread in the spring. We have in reality five parallel experiments yearly, the area of each sub-plot being about one-quarter of an acre. The crop last year was ensilage corn. On three plots the yield where the manure was spread in the spring was considerably greater than where it was spread in the winter; on the other two plots the yields under the two systems of application were practically equal. Rye was sown in the standing corn on August 20, to furnish winter cover. This rye had made considerable growth, which was fairly even on all the plots when it was plowed under, the middle of May. The crop of this year was soy beans, five different varieties being planted, each kind in equal area on all the plots. Owing to the cold weather, the growth was not altogether satisfactory, and the yield even of the earliest varieties was small. It was seen that one variety would not ripen, and accordingly it was cut when in ensilage condition and put into the silo. We have, therefore, to report for each plot the rate of yield per acre of dry beans and straw, and of green forage for the silo. The rates of yield per acre and the relative standing of the several plots are shown in the tables: —

Actual and Relative Yields of Green Forage.

Plots.	MANURING PREVIOUS TO 1889.	ACTUAL YIELDS (RATES PER ACRE, POUNDS).		RELATIVE YIELDS (PER CENT.).	
		North Half, Winter Application.	South Half, Spring Application.	North Half, Winter Application.	South Half, Spring Application.
1, .	Barnyard manure, . .	10,785	9,729	100	90.21
2, .	Wood ashes, . . .	9,821	8,811	100	89.72
3, .	No manure, ...	9,041	9,408	100	104.06
4, .	Fine-ground bone and muriate of potash.	9,546	11,519	100	120.67
5, .	Fine-ground bone and sulfate of potash.	10,509	11,840	100	112.66

Actual and Relative Yields of Soy Beans and Straw.

Plots.	MANURING PREVIOUS TO 1889.	ACTUAL YIELDS (RATES PER ACRE).			
		BEANS (BUSHELS).		STRAW (POUNDS).	
		North Half, Winter Application.	South Half, Spring Application.	North Half, Winter Application.	South Half, Spring Application.
1, .	Barnyard manure, . .	14.56	15.56	1,021	1,212
2, .	Wood ashes, . . .	16.27	15.50	1,272	1,319
3, .	No manure, ...	15.04	14.42	1,232	1,119
4, .	Fine-ground bone and muriate of potash.	15.22	12.55	1,284	1,045
5, .	Fine-ground bone and sulfate of potash.	14.26	15.21	1,252	1,269

Actual and Relative Yields of Soy Beans and Straw — Concluded.

Plots.	MANURING PREVIOUS TO 1889.	RELATIVE YIELDS (PER CENT.).			
		BEANS.		STRAW.	
		North Half, Winter Application.	South Half, Spring Application.	North Half, Winter Application.	South Half, Spring Application.
1, .	Barnyard manure, . .	100	106.87	100	118.71
2, .	Wood ashes, . . .	100	95.27	100	103.69
3, .	No manure, ...	100	95.88	100	90.83
4, .	Fine-ground bone and muriate of potash.	100	82.46	100	81.39
5, .	Fine-ground bone and sulfate of potash.	100	106.66	100	101.36

In previous years the south half (spring manured) of each plot has, with two insignificant exceptions, above noted in the case of the ensilage corn of last year, given a greater yield than the north half. The yield of the winter-manured portion for each year being considered 100 for the several plots, the yields of the spring-manured portion of the same plots has varied in the different years as follows: in 1900, from 103 to 125; in 1901, from 118 to 177; in 1902, from practical equality in two cases to 150. This year, it will be noted, there is but little difference in the yields under the two systems of manuring, and the advantage is on the side of the winter application. The winter application considered as 100 as in previous years, the yields for the spring application of manures has varied as follows: for the beans, 82.46 to 106.87; for the straw, 81.39 to 118.71; and for the green forage, 89.72 to 120.67.

In attempting to understand the reasons for such differences as have been noted in the different years, we find, on a study of the weather conditions, that those of the winter of 1902 and 1903 were for this locality quite exceptional. A heavy snowfall came during the first week in December, at which time the ground was not frozen. This snow, with occasional additions from time to time, though sometimes wasting to some extent, lay upon the ground throughout the winter in sufficient amount to prevent the ground from freezing. The winter was without those frequent sudden thaws, accompanied by heavy rains, which with frozen ground lead to excessive washing. So remarkable was the winter that the roots of one of our exceptionally hardy summer crops, dwarf Essex rape, came out in the spring uninjured, and with the approach of warm weather sprouted and made vigorous growth. Under such conditions it is not strange that loss of the soluble plant food constituents of the manure spread upon the surface took place to a very slight extent, if at all. Could we depend upon such winters as the last, the practice of spreading manure and leaving it upon the surface during the winter would undoubtedly be wise, as it saves on the cost of handling; but, as every one familiar with our climate understands, such winters cannot be depended upon, and accordingly the weight of evidence in our experiments is still in favor of hauling the manure into heaps, to remain over winter and to be spread in the spring.

IX. — Poultry Experiments.

In our experiments with poultry during the past year our attention has been confined almost exclusively to questions connected with the feeding of fowls for eggs. We are endeavoring to obtain light on the question as to the proper relation between the different nutrients in the ration fed. Our work during the year may be summarized as follows: —

1. We have compared two rations, in one of which corn is prominent, in the other wheat, using animal meal as a source of animal food. The nutritive ratio of the ration including wheat has been 1 : 4.34; for the one including corn, the ratio has been 1 : 6.24.

2. We have compared two rations in which respectively corn and wheat are prominent, with milk albumin as the source of animal food in each, and with an addition of corn oil as a source of fat, in which the milk albumin is very poor. The nutritive ratio of the ration including wheat is 1 : 4.44; for the ration including corn, 1 : 6.48.

3. We have compared two rations in one of which wheat is prominent, in the other rice, with milk albumin as the source of animal food in each. Both of these rations were very low in fat. The nutritive ratio of the first (in which wheat is prominent) is 1 : 4.3; of the second (in which rice is prominent), 1 : 6.4.

The most important points in connection with the results appear to be as follows: —

1. In the comparison of wheat with corn, where animal meal was the source of animal food, the egg production for the entire period from December 14 to September 4 was practically equal. For the winter period, December 14 to April 1, the corn ration produced eggs at an average rate of .3005 per hen day; the wheat ration, at the rate of .2792 per hen day. In other words, 100 hens on the corn ration would have given an average daily yield of a slight fraction over 30 eggs, while the wheat ration would have given from the same number of hens almost 28 eggs per day. For the summer period, April 1 to September 4, the corn ration gave an average of .4365 eggs per hen day; the wheat ration,

.4541; or, in other words, the average daily product from 100 hens would have been for the wheat ration 44.4 eggs; for the corn ration, about 43.7. The average food cost per egg produced was on the wheat ration, a very slight fraction over 1 cent; on the corn ration it was .85 of a cent.

2. In the comparison of wheat with corn, with milk albumin as the source of animal food in each, and with corn oil added as a source of fat, the egg product was considerably better than in the first experiment. For the entire period the hens receiving corn produced more eggs, — an average at the rate of .4166 eggs per hen day. For the wheat the similar average was .3570. For the winter period, December 14 to April 1, similar averages were: for the wheat ration, .2606; for the corn ration, .2862. For the summer period, April 1 to September 4, the averages were: for the wheat, .4251; for the corn, .5107. For the entire period the average food cost per egg laid was for the wheat ration 1 cent, for the corn ration .8 cent. The product obtained in this experiment, at the rate respectively for the wheat of 35.7 eggs per day and for the corn at the rate of 41.66 eggs per day, for 100 hens is considered good, for fowls kept in close confinement, especially in view of the fact that the pullets used in the experiment were rather late hatched, and laid but few eggs until the first of February, viz., 125 for the fowls receiving wheat and 48 for the fowls receiving the corn ration.

3. In the comparison of wheat with rice, with milk albumin as the source of animal food in each, the results were decidedly in favor of the ration including the rice. For the entire period the product of these fowls was at the rate of .3732 eggs per hen day; for the fowls receiving the wheat, at the rate of .3328 eggs per hen day. For the winter period, December 14 to April 1, the averages were: for the rice ration, .3097; for the wheat ration, .2241 eggs per hen day. For the summer period, April 1 to September 4, similar averages were: for the rice, .4188; for the wheat, .4080. The production in this experiment is inferior on both rations to that obtained in either of the other experiments; and, although the yield on the rice is fairly good, this cannot be

regarded as a practical food for ordinary use, on account of its high cost. The food cost for the eggs produced in this experiment was at the rate of about $1\frac{1}{5}$ cents for the wheat ration, and nearly 2.1 cents per egg for the rice ration.

As the result of experiments in previous years, corn had been found superior to wheat rations when animal meal was used as the source of animal food, while with scraps the two rations gave nearly equal numbers of eggs. In previous experiments, with milk albumin as the source of animal food, the egg production has usually been unsatisfactory when wheat has been the principal grain. These facts had led to the belief that possibly the amount of fat in the ration played an important part in determining the egg yield ; and the experiments of this year were planned with a view to throwing light upon this point. In some particulars they seem to confirm this theory. The production of eggs on milk albumin, which is very low in fat, has in previous years been quite unsatisfactory. This year, with the addition of fat, more eggs have been produced. Further, in other experiments the egg production where corn is the principal grain has much exceeded that where wheat is the principal grain, when animal meal is used as the source of animal food. The results this year were very similar. On the other hand, the ration lowest in fat of all, viz., that including rice, has given many more eggs than the ration including wheat, which furnishes a far greater quantity of fat.

A study of the rations of this year shows an apparent relation between the quantity of fiber in the food and the egg production. The rations furnishing exceptionally large amounts of fiber, derived principally from such grains as oats and barley, have given very inferior yields of eggs.

In conclusion, we are justified in saying that our experiments do not lend support to the belief that the nutritive ratios of rations fed to hens must necessarily be narrow to produce a satisfactory product. We have obtained more eggs in winter in all experiments this year on the combinations of foods with the wider nutritive ratios, and in two out of three experiments the result was the same for the summer period. I am still inclined to the belief that the amount of fat in the ration is a matter of much importance. I believe, further, that care should be taken that the ration does not include too large a proportion of fiber, as this without doubt increases the labor of digestion, and probably decreases the proportion of the various nutrients digested and assimilated. It is well understood that animal matter of some kind is essential to good egg production. Our earlier experiments have shown the great superiority of animal to vegetable protein in rations for laying hens. It is believed, however, that suitable animal feeds, under which class may be included all such as are well preserved and sweet and palatable, may be wisely used in connection with a large proportion of our cheapest grain, — corn.

REPORT OF THE DEPARTMENT OF HORTICULTURE.

F. A. WAUGH, HORTICULTURIST; GEO. O. GREENE, ASSISTANT.

The work of the department of horticulture during the year just closing has been devoted largely to reorganization, and to the beginning of new lines of experiment and new systems of record. The various experiments undertaken will be reported upon as fast as valuable results develop. Meanwhile, the department continues to find a large part of its public service in answering various inquiries from all over Massachusetts and neighboring States. Such inquiries, touching all the subjects connected with fruit and vegetable growing, arboriculture and landscape gardening, are answered promptly, and as fully as circumstances permit.

The work of testing new and old varieties of fruits and vegetables has been considerably abated, but has not been suddenly nor inconsiderately abandoned. The comparison of varieties of strawberries, for example, which has long been a feature of the department work, has been continued for the present on a somewhat different plan, and some report of results is a part of the present publication.

Mr. George A. Drew, who has been assistant horticulturist and in charge of various lines of experimental work for several years, resigned that position in September, to take up more remunerative work elsewhere. The vacancy was filled October 1 by the appointment of Mr. George O. Greene, assistant horticulturist of the Kansas Experiment Station. The high character of the service performed by Mr. Drew during his term as assistant should be a matter of special recognition and record here.

STRAWBERRY EXPERIMENTS.

Experiments with strawberries, which have been carried on for many years in the department of horticulture, have been continued for the present. This work has been under the direct charge of Mr. George A. Drew, and the following notes have largely been made up by him.

Season and Soils.

The season of 1903 was a disappointment in many respects to strawberry growers. To start with, a number of the early varieties were damaged by spring frosts; then, when the later fruit was about ready to mature, a severe drought set in, lasting practically throughout the fruiting season, and very naturally reducing the yield.

While disappointing from the commercial grower's standpoint, the season was not without some instructive features as regards behavior of varieties and the ability of certain soils to retain moisture. Where the soil had been very thoroughly prepared, and there was an abundance of vegetable matter present, the strawberry plant withstood the dry weather without very serious damage; on the other hand, where the soil was of a gravelly nature, and the amount of vegetable matter limited, the plant easily succumbed to the effects of the drought.

It cannot be emphasized too much or repeated too often how great a part thorough preparation of the soil takes in the yields obtained. The strawberry naturally has a very limited root system, and any means that will induce the fibers to penetrate deeper is labor well spent.

A medium deep loam is, all things considered, about the ideal soil. If one depends on a sandy or gravelly soil, irrigation facilities must be provided, and, taken one year with another, some system of irrigation will undoubtedly pay. If one does not feel justified in the outlay this would necessitate, and one has several kinds of soil to choose from, it is well to select two different types: one gravelly, light and early; the other more loamy, heavier and later. Then, after a series of years, one could balance up accounts, so to speak, and find which was the most profitable in the long run.

Notes on Varieties.

Many new and old varieties have been compared on different soils, ranging from rather dry gravel to fine rich loam. Those varieties which, on account of their novelty, their special value or other interest, seem worthy of report, are described and commented on below.

August Luther. — Fruit: oblong; size, small; core, melting; external color, scarlet; color of flesh, light pink; flavor, sweet; season, early; calyx, small, loose; texture, medium; seeds, yellow, imbedded; quality, good; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, fair; runners, many; rust, none.

Sets a large amount of fruit, but has no special points of merit.

Belmont. — Fruit: oblong, flattish, irregular; size, very large; core, slightly hollow; external color, crimson; color of flesh, red to core; flavor, slightly acid; season, medium to late; calyx, large, loose; texture, firm; seeds, yellow, imbedded; quality, good; shipping quality, good. Blossom, perfect; runners, numerous; rust, very slight.

Not very productive, but attractive in appearance, and one of the good old kinds.

Bismarck. — Fruit: roundish; size, medium large; core, small, hard and closed; external color, scarlet; color of flesh, light pink; flavor, sweet; season, early to medium; calyx, medium loose; texture, medium; seeds, yellow, prominent; quality, very good; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, good; runners, numerous; rust, none.

A good home berry, and fairly productive.

Blonde. — Fruit: conic, regular; size, medium large; core, slightly open; external color, light crimson; color of flesh, reddish; flavor, acid; season, late; calyx, large, loose; texture, firm; seeds, brownish, prominent; quality, fair; shipping quality, good. Blossom, imperfect; plant, vigorous; foliage, good; runners, numerous; rust, slight.

Brandywine. — Fruit: round, conic, tapers to sharp point; size, large; core, slightly open; external color, dark crimson; color of flesh, red throughout; flavor, acid; season, medium to late; calyx, green, loose and prominent; texture, firm; seeds, yellow, prominent; quality, good; shipping quality, fair. Blossom, a good pollenizer, perfect; plant, vigorous; foliage, dark, large and regular; runners, numerous; rust, slight.

Productive generally, but the fact of berry turning black where exposed to the air proves a great drawback; erratic in different localities.

Brunette. — Fruit: round, conic; size, large; core, slightly hollow; external color, crimson; color of flesh, crimson; flavor, insipid; season, medium; calyx, medium loose; texture, medium; seeds, yellow, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, good; runners, numerous; rust, none.

A valuable home variety.

Bubach. — Fruit: flat, conical; size, large; core, hollow; external color, dark scarlet; color of flesh, scarlet; flavor, insipid; season, early to medium; calyx, medium; texture, medium; seeds, greenish, prominent; quality, fair; shipping quality, fair. Blossom, perfect; plant, deficient in vigor; foliage, medium dark, medium large; runners, medium; rust, slight.

Deficient in vigor, and, like the Marshall, succeeds only in favored localities, where one can get a fine healthy stock of plants.

Bush Cluster. — Fruit: usually conical; size, medium large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, acid; season, medium; calyx, medium loose; texture, medium; seeds, imbedded; quality, poor; shipping quality, fair. Blossom, imperfect; plant, fairly vigorous; foliage, large, medium dark; runners, numerous; rust, slight.

A disappointment in all respects.

Clyde. — Fruit: irregular, conic; size, large to very large; core, slight; external color, scarlet; color of flesh, scarlet; flavor, sub-acid; season, early; calyx, loose, large; texture, medium; seeds, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, deficient in vigor; foliage, medium, large, light; runners, very numerous; rust, slight.

Extremely productive, and tends to set more fruit than it is capable of maturing; somewhat subject to disease.

Cobden Queen. — Fruit: round, irregular, conic; size, medium large; external color, dark scarlet; color of flesh, scarlet; flavor, acid; season, medium; calyx, medium; texture, firm; seeds, prominent outside; quality, good; shipping quality, good. Blossoms, rather few, imperfect; runners, numerous; rust, slight.

Foliage unhealthy; fruit seedy.

Corsican. — Fruit: round to roundish, conic; size, medium; core, slightly hollow; external color, scarlet; color of flesh, pinkish; flavor, insipid; season, early to medium early; calyx, medium; texture, soft; seeds, yellow, outside; quality, fair; shipping quality, poor. Blossom, perfect; plant, vigorous; foliage, inclined to discolor; runners, fair; rust, slight.

Too soft for commercial use; always a disappointment here.

Darling. — Fruit: round, conic; size, medium; core, medium; external color, scarlet; color of flesh, light scarlet; flavor, insipid; season, medium; calyx, medium; texture, medium; seeds, yellow, prominent; quality, fair. Blossom, perfect; plant, deficient in vigor; rust, slight.

Too poor for commercial use.

Delaware. — Fruit: flat, conical, irregular; size, medium; core, medium to large; external color, crimson; color of flesh, crimson; flavor, acid; mid-season; calyx, rather prominent; texture, firm; seeds, yellow, prominent; quality, poor; shipping quality, very good. Blossom, perfect; plant, medium in vigor; foliage, medium; runners, medium; rust, little.

Rather unproductive, but set some fine fruit of good color and shipping quality.

Dewey. — Fruit: long, conic; size, medium large; core, small, hard; external color, scarlet; color of flesh, scarlet; flavor, acid; season, medium; calyx, medium; texture, firm; seeds, yellow, prominent; quality, fair; shipping quality good. Blossom, perfect; plant, fairly vigorous; foliage, medium green; runners, medium; rust, slight.

Inclined to be deficient in vigor, and nothing of special merit to recommend it.

Dole. — Fruit: irregular, conical; size, medium large; core, medium large; external color, scarlet; color of flesh, light scarlet; flavor, sweet; season, medium; calyx, medium; texture, rather soft; seeds, yellow, imbedded; quality, good; shipping quality, poor. Blossom, imperfect; plant, vigorous; foliage, good; runners, many; rust, little.

Unproductive; possesses no special advantage over others.

Drought King. — Fruit: round, conical, and irregular; size, medium; core, slight, hard; external color, scarlet; color of flesh, whitish; flavor, very acid, sour; season, medium; calyx, medium; texture, firm; seeds, brownish, prominent; quality, very good; shipping quality, good. Blossom, imperfect; rust on plant, slight.

Unworthy of its name; very poor.

Gibson. — Fruit: flat, conical; size, large to very large; core, small, hollow; external color, dark crimson; color of flesh, red throughout; flavor, slightly acid; season, medium; calyx, medium large; texture, firm; seeds, yellow, prominent; quality, fair; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, healthy, vigorous; runners, few; rust, slight.

Unproductive here, but very fine fruit, and worthy of further trial.

Gladstone. — Fruit: irregular, conic, like Glen Mary; size, large to very large; core, hard; external color, scarlet; color of flesh, pinkish; flavor, acid; season, medium; calyx, loose medium; seeds, yellow, imbedded; quality, fair; shipping quality, good. Blossom, perfect; plant, vigorous; foliage, large, medium green; runners, numerous; rust, slight.

Resembles Glen Mary closely.

Glen Mary. — Fruit: irregular, conical; size, large; core, hard; external color, crimson; color of flesh, crimson; flavor, acid; season, medium; calyx, medium; texture, firm; seeds, yellow, prominent; quality, poor; shipping quality, good. Blossom, perfect; plant, very vigorous; foliage, large, vigorous; runners, numerous; rust, slight.

Greatest fault in uneven ripening of tips of berries, but large and productive.

Haverland. — Fruit: long, conical; size, medium large to large; core, slight; external color, scarlet; color of flesh, scarlet; flavor, sweet; season, early; calyx, medium; texture, medium; seeds, slightly imbedded; quality good; shipping quality, good. Blossom, imperfect; plant, very vigorous; foliage, large, long; runners, many; rust, slight.

Very productive, and one of the best for commercial and domestic use; one of the leaders still.

Hawaii. — Fruit: long, conic; size, medium; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, sweet; season, early; calyx, medium; texture, medium; seeds, yellow, slightly imbedded; quality, good; shipping quality, good. Blossom, perfect; plant, vigorous; foliage, resembles Haverland; runners, numerous; rust, slight.

Resembles Haverland closely, but not so productive nor so large fruit.

Hero. — Fruit: flat, conical; size, medium large; core, medium; external color, dark scarlet; color of flesh, red to core; flavor, acid; season, medium; calyx, medium; texture, firm; seeds, yellow, prominent; quality, good; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, good; runners, few; rust, slight.

Not very vigorous or productive, and a disappointment here.

Howard 7. — Fruit: irregular, inclined to be in two parts; size, large; core, large, open, hollow; external color, crimson; color of flesh, crimson to core; flavor, acid; season, medium; calyx, large, upturned; texture, firm; seeds, yellow, imbedded; quality, poor; shipping quality, good. Blossom, imperfect; plant, vigorous; foliage, dark, medium large; runners, average; rust, slight.

Worthy of further trial.

Howard 14. — Fruit: very long, tapering at each end; size, large; core, slight, slightly hollow; external color, dark scarlet; color of flesh, scarlet; flavor, sweet; season, early to medium; calyx, medium large; texture, firm; seeds, yellow, imbedded; quality, good; shipping quality, good. Blossom, imperfect; plant, very vigorous; foliage, very tall, long leaf stalks; runners, many; rust, little.

Inclined to run small after first few pickings.

Howard 36. — Fruit: long, flat, conical, somewhat tapering at point; size, large; core, slight; external color, dark scarlet; color of flesh, scarlet; flavor, slightly acid; season, medium to early; calyx, medium loose; texture, firm; seeds, yellow, imbedded; quality, fair; shipping quality, good. Blossom, imperfect; plant, vigorous; foliage, medium large, vigorous; runners, many; rust, little.

One of the most productive and profitable varieties on our ground.

Howard 103. — Fruit: round, conical; size, large; core, closed, slight; external color, crimson; color of flesh, crimson; flavor, acid; season, very early; calyx, medium, rather loose; texture, rather soft; seeds, yellow, deeply imbedded; quality, fair; shipping quality, fair.

Blossom, imperfect; plant, fairly vigorous; foliage medium, dark and vigorous; runners, medium; rust, none.

A good, productive, very early berry, and for this purpose excels.

Howard's Clyde 3. — Fruit: round, conic, slightly irregular, often divided; size, large; core, slight, closed; external color, scarlet; color of flesh, scarlet; flavor, slightly acid; season, early; calyx, medium large, loose; texture, slightly soft; seeds, light yellow, imbedded; quality, good; shipping quality, good. Blossom, perfect; plant, vigorous; foliage, medium dark, large; runners, numerous; rust, none.

Does not set as much fruit as Clyde, but matures it better; an improvement on Clyde, and valuable.

Joe. — Fruit: round, conic; size, large to very large; core, slight; external color, scarlet; color of flesh, scarlet; flavor, sweet; season, medium; calyx, loose, medium large; texture, firm; seeds, yellow, prominent; quality, good; shipping quality, good. Blossoms, medium in number, large, perfect; plant, vigorous; foliage, large, dark; runners, fair; rust, slight.

Not very productive, but promising as a large, juicy berry; fancy.

Jucunda. — Fruit: roundish; size, large; core, medium; external color, crimson; color of flesh, crimson; flavor, acid; season, medium; calyx, green; texture, firm; seeds, yellow, prominent; quality, good; shipping quality, good. Blossom, perfect; plant, vigorous; foliage, large, dark, on short stalks; runners, medium; rust, slight.

Still worthy of cultivation, though deficient in vigor.

Kansas. — Fruit: round, conic; size, medium; core, slightly hard; external color, scarlet; color of flesh, light scarlet; flavor, sub-acid; season, early to medium; calyx, medium loose; texture, medium; seeds, yellow, imbedded; quality, fair; shipping quality, fair. Blossom, imperfect; plant, vigorous; foliage, medium vigorous; runners, very numerous; rust, slight.

Not to be recommended, according to its behavior on our grounds.

Klondike. — Fruit: irregular, conic; size, very large; core, slight; external color, dark scarlet; color of flesh, scarlet; flavor, insipid; season, medium; calyx, large; texture, medium; seeds, brown, imbedded; quality, poor; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, light; runners, numerous; rust, slight.

Inclined to ripen unevenly, and too soft for transportation a long distance; valuable home variety.

Latest. — Fruit: irregular, conic; size, large to very large; core, hard; external color, dark scarlet; color of flesh, whitish; flavor, insipid; season, late; calyx, loose; texture, medium firm; seeds, brown, deeply imbedded; quality, fair; shipping quality, fair. Blossom, imperfect; plant, medium vigorous; foliage, medium; runners, few; rust, slight.

Plants stock up well and are fairly productive; promising late variety.

Leheman 2. — Fruit: irregular, conical; size, large; core, hard; external color, dark scarlet; color of flesh, light scarlet; flavor, acid; mid-season; calyx, small; texture, firm; seeds, yellow, prominent; quality, poor; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, leaves long, medium large; runners, numerous; rust, slight.

Productive and reliable.

Lester. — Fruit: conical; size, large; core, slight; external color, dark scarlet; color of flesh, scarlet; flavor, acid; season, medium; calyx, large, loose, prominent; texture, firm; seeds, prominent; quality, good; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, thick; runners, fair; rust, none.

Lyon. — Fruit: long, conic; size, large; core, slight; external color, dark scarlet; color of flesh, scarlet; flavor, sweet; season, early to medium; calyx, loose; texture, medium; seeds, prominent; quality, good; shipping quality, good. Blossom, thrifty, imperfect; plant, vigorous; runners, numerous; rust, slight.

Very productive, medium-sized berries.

M. A. C. Seedling 24. — Fruit: round, conic; size, large to very large; core, inclined to be hollow; external color, crimson; color of flesh, light crimson; flavor, insipid; season, early to medium; calyx, medium; texture, rather soft; seeds, brown, imbedded; quality, fair; shipping quality, fair. Blossom, not very vigorous, perfect; plant, only fair in vigor; foliage, medium large; runners, fair; rust, considerable.

Inclined to be soft for long transportation, but otherwise very good.

Margaret. — Fruit: irregular, conic; size, large; core, slight; external color, crimson; color of flesh, pinkish; flavor, sweet; season, early to medium; calyx, loose, prominent; texture, very firm; seeds, prominent; quality, good; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, medium green; runners, fair; rust, slight.

Not very productive, but occasionally to be recommended.

Marshall. —Fruit: irregular, conic; size, large; core, slight; external color, crimson; color of flesh, crimson; flavor, sweet; season, medium; calyx, loose, prominent; texture, firm; seeds, yellow, prominent; quality, standard; shipping quality, good. Blossom, perfect; foliage, large, dark, heavy; rust, slight.

Not productive, but fine for home use; success with this variety depends mainly on selection of plants and favored localities and on high cultivation.

McFarland's Seedling. — Fruit: elongated; size, very large; core, slight; external color, dark scarlet; color of flesh, light scarlet; flavor, rather insipid; season, medium; calyx, large, loose; texture, firm; seeds, brownish, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, large, dark; runners, numerous; rust, slight.

Very productive and promising, where large fancy fruit is desired.

McKinley. — Fruit: irregular, long, flat; size, large to very large; core, slight; external color, dark scarlet; color of flesh, light scarlet; flavor, insipid; season, medium; calyx, loose, large, prominent; texture, rather soft; seeds, golden, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, vigorous; runners, fair; rust, slight.

Greatest fault is soft fruit and uneven ripening; similar to Meggansett Dew Drop.

Mead's Seedling. — Fruit: round, conic; size, medium large to large; core, slight; external color, scarlet; color of flesh, scarlet; flavor, sub-acid; season, medium; calyx, medium, loose; texture, medium; seeds, yellow; quality, fair; shipping quality, fair or rather poor. Blossom, perfect; plant, vigorous; foliage, medium dark; runners, numerous; rust, slight.

Originated by H. O. Mead of Lunenburg, Mass. Inclined to become soft on standing.

Meggansett Dew Drop. — Fruit: long, irregular, conical; size, large to very large; core, slight; external color, scarlet; color of flesh, whitish; flavor, insipid; season, early to medium; calyx, loose; texture, medium fine; seeds, yellow, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, very vigorous; foliage, dark; runners, numerous; rust, none.

General tendency to color unevenly, and rather soft for shipping; resembles McKinley somewhat; productive.

Morgan. — Fruit: long, flattish; size, large to very large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, insipid; season, medium early; calyx, large, rather loose; texture, medium firm; seeds, yellow, prominent; quality, fair; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, medium dark; runners, numerous; rust, slight.

Greatest fault is general tendency to color unevenly; productive.

Nettie. — Fruit: long, irregular, conic; size, very large; core, slight; external color, scarlet; color of flesh, scarlet; flavor, acid; season, late; calyx, loose, large; texture, firm; seeds, yellow, imbedded; quality, fair; shipping quality, fair. Blossom, imperfect; plant, vigorous; foliage, dark, large; runners, fair; rust, slight.

Appears to be a promising late variety, where size and appearance count; fancy.

New York. — Fruit: long, irregular, conic; size, large; core, medium; external color, scarlet; color of flesh, light scarlet; flavor, insipid; calyx, medium loose; texture, medium firm; seeds, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, vigorous; foliage, fair; rust, slight.

Inclined to be too light colored, otherwise a productive fancy berry.

Nick Ohmer. — Fruit: roundish; size, large; core, slight; external color, scarlet; color of flesh, whitish; flavor, sweetish; season, medium; calyx, medium, rather loose; texture, firm; seeds, imbedded; quality, good; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, diseased; runners, numerous; rust, slight.

Plant deficient in vigor, and not productive; some very good fruit, but not to be relied upon.

Pacific. — Fruit: broad, flattish, conical; size, medium large; core, slight; external color, crimson; color of flesh, light crimson; flavor, acid; calyx, medium loose; texture, firm; seeds, yellow, imbedded; quality, fair; shipping quality, good. Blossom, imperfect; plant, vigorous; foliage, medium; runners, numerous; rust, slight.

Productive, and a good early berry.

Paris King. — Fruit: long, irregular, conic; size, medium large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, rather acid; season, early; calyx, medium loose; texture, firm; seeds, yellow; quality, fair; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, medium green; runners, numerous; rust, slight.

A good, productive, early berry.

Parson's Beauty. — Fruit: irregular, conic; size, large; core, slight; external color, crimson; color of flesh, crimson; flavor, acid; season, early to medium; calyx, medium loose; texture, firm; seeds, yellow, imbedded; quality, good; shipping quality, good. Blossoms, numerous, perfect; plant, vigorous; foliage, dark, medium thick; runners, very numerous; rust, slight.

Productive, but berries not uniform, and hence not very attractive in appearance.

Pennell. — Fruit: flattish, irregular, conic; size, large; core, hard; external color, crimson; color of flesh, crimson; flavor, acid; mid-season; calyx, loose; texture, firm; seeds, very prominent, numerous; quality, rather poor; shipping quality, good. Blossom, perfect; plant, fairly vigorous; foliage, fair; runners, numerous; rust, slight.

Prominent seeds on outside give unattractive appearance, otherwise a valuable addition.

Plymouth Rock. — Fruit: roundish; size, medium large; core, slight; external color, crimson; color of flesh, light crimson; flavor, sweet; season, medium; calyx, loose; texture, firm; seeds, prominent; quality, good; shipping quality, good. Blossom, vigorous; plant, fairly vigorous; foliage, fair; runners, fair; rust, slight.

Fairly productive, but fruit not uniform.

Pocomoke. — Fruit: irregular, conical; size, large to very large; core, medium; external color, crimson; color of flesh, crimson; flavor, acid; mid-season; calyx, loose; texture, firm; seeds, yellow, prominent; quality, fair; shipping quality, good. Blossom, vigorous, perfect; plant, has good vigor; foliage, medium large; runners, fair; rust, slight.

Productive and promising; a good commercial variety, to be recommended.

Pomona. — Fruit: round, conic; size, medium large; core, slight;

external color, dark scarlet; color of flesh, light scarlet; flavor, insipid; season, early to medium; calyx, medium loose; texture, medium; seeds, imbedded; quality, fair; shipping quality, fair. Blossom, full, perfect; plant, fairly vigorous; foliage, fair; runners, numerous; rust, slight.

Averages favorably with the commercial sorts.

Porto Rico. — Fruit: long, conical, small neck; size, medium large; core, slight; external color, crimson; color of flesh, light crimson; flavor, sub-acid; season, medium; calyx, loose, upturned; texture, firm; seeds, brownish; quality, good; shipping quality, very good. Blossoms, medium in number, imperfect; plant, fairly vigorous; foliage, fair; runners, average, or below; rust, slight.

Parker Earle type; productive, and worthy of more extended trial.

Premium. — Fruit: conical; size, medium large; core, slight; external color, scarlet; color of flesh, scarlet; flavor, acid; season, early to medium; calyx, medium; texture, firm; seeds, imbedded; quality, rather poor; shipping quality, good. Blossom, imperfect; plant, fairly vigorous; foliage, medium dark; runners, numerous; rust, slight.

Good average berry, but inclined to run small by mid-season.

Pride of Cumberland. — Fruit: round, conic; size, medium large; core, slight; external color, light crimson; color of flesh, light crimson; flavor, sub-acid; mid-season; calyx, medium loose; texture, very firm; seeds, yellow, protruding; quality, very good; shipping quality, very good. Blossoms, medium in number, perfect; plant, fairly vigorous; foliage, fair; runners, comparatively few; rust, slight.

Not very productive on our soil, but otherwise a good commercial berry.

Putnam's Seedling X. — Fruit: round, conic; size, large; core, medium; external color, scarlet; color of flesh, scarlet; flavor, acid; season, late; calyx, large; texture, very firm; seeds, yellow, slightly imbedded; quality, good; shipping quality, very good. Blossom, vigorous, imperfect; plant, has good vigor; foliage, medium; runners, average; rust, slight.

Fine, firm, regular late berry.

Rochester. — Fruit: irregular, conic; size, medium large; core, slight; external color, crimson; color of flesh, crimson; flavor, sweet; season, medium; calyx, medium; texture, firm; seeds, yellow, protruding; quality, poor; shipping quality, good. Blossoms, many, perfect; plant, fairly vigorous; foliage, medium; runners, numerous; rust, slight.

Not to be recommended for commercial planting, from its behavior on our grounds.

Rough Rider. — Fruit: irregular; size, medium large; core, hard; external color, crimson; color of flesh, crimson; flavor, acid; mid-season; calyx, rather loose, medium; texture, firm; seeds, yellow, imbedded; quality, rather poor; shipping quality, good. Blossoms, medium in number, perfect; plant, poor in vigor; foliage, fair; runners, fair; rust, slight.

Nothing to recommend it, according to its behavior here.

Sample. — Fruit: round, conic, regular; size, large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, sub-acid; mid-season; calyx, medium; texture, medium; seeds, brownish; quality, fair; shipping quality, fair to good. Blossom, vigorous, imperfect; plant, has good vigor; foliage, medium green; runners, numerous; rust, slight.

A fine, productive, uniform commercial berry, inclined at times to be a little soft; still the most reliable, under various conditions.

Sawyer's Seedling. — Fruit: round, conic; size, medium large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, sub-acid; season, medium to late; calyx, medium; texture, firm; seeds, yellow, imbedded; quality, fair; shipping quality, good. Blossom, fairly vigorous, perfect; plant, very good in vigor; foliage, large, vigorous; runners, average; rust, slight.

Satisfactory on our grounds; productive and valuable.

Shuster's Gem. — Fruit: round, conic; size, large; core, slight; external color, crimson; color of flesh, lightish; flavor, sub-acid; mid-season; calyx, large; texture, medium; seeds, yellow, protruding; quality, fair; shipping quality, fair. Blossom, perfect; plant, has good vigor; foliage, medium dark; runners, average; rust, slight.

An old reliable berry, and worthy of culture.

Springdale Beauty. — Fruit: irregular, roundish; size, medium to large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, sub-acid; season, early to medium; calyx, loose; texture, medium; seeds, yellow, slightly imbedded; quality, fair; shipping quality, fair. Blossom, vigorous, perfect; plant, vigorous; foliage, medium dark; runners, average in number; rust, slight.

A good general-purpose berry.

Uncle Jim. — Fruit: long, conical; size, large to very large; core, slight; external color, dark scarlet; color of flesh, light scarlet; flavor, rather insipid; season, medium; calyx, medium loose; texture, firm; seeds, yellow, imbedded; quality, fair; shipping quality, fair. Blossom, perfect; plant, very good in vigor; foliage, resembles Marshall; runners, numerous; rust, none.

Sets moderate amount of fruit, and matures it; one of the most promising newly introduced varieties; fancy.

Uncle Sam. — Fruit: round, conic; size, large; core, slight; external color, scarlet; color of flesh, light scarlet; flavor, insipid; season, medium late; calyx, large, loose; texture, firm; seeds, brown, imbedded; quality, fair; shipping quality, good. Blossom, perfect, and good pollenizer; plant, vigorous; foliage, dark; runners, comparatively few; rust, slight.

Stocks up well in hill system, but rather light color for a market berry, and only moderately productive.

Cultural Methods.

The department has constantly experimented with methods of cultivation; and, since this work has covered many years and a diversity of soils, some general remarks on the management of strawberry plantations may appear to be in place. While the cultural methods of growing the strawberry vary widely, and each system has its special devotees, nearly all methods have merits and demerits worth considering.

Shall the strawberry plant be allowed to fruit one or two years? Nearly all the best growers now practise the former method. By this quick rotation fungous and insect pests are avoided to a greater extent, and the fruit is generally considered enough better to warrant the extra labor and expense.

Shall the plants be set in the early spring, or in autumn? Generally speaking, our experience has shown that spring setting is best, as the root system gets a better chance to develop, and the crown to store up nutriment for fruit bearing the following year. However, in special cases good results are obtained by selecting vigorous plants in July and August, setting in beds close together, and allowing no runners to form.

There are four general systems, modified more or less to suit special conditions; these are commonly practised with spring setting: the hill system, hedge-row system, narrow matted row and wide matted row systems.

The hill system is more generally advocated by amateur than commercial growers. The plants should be set out about two and one-half by two feet, and no runners allowed to form. Everything that will aid the crown to increase in size and strength should be provided. The larger and more vigorous the crowns, the greater the results; the strength of the plants goes to building up a fruit-producing organism alone. Another great advantage is the exposure to air and sunlight on all sides, and the consequent production of better-colored, better-flavored and firmer fruit, worthy of a fancy price.

The hedge-row system is a modification of the hill system in many respects. The plants should be set out about the same distance apart, or possibly in rows three feet apart. The first vigorous runners are then trained in a line with the parent plants, but not detached from them. When this line is filled out so as to make one continuous row, with plants about four or five inches apart, no more runners should be allowed to form. This system possesses nearly all the advantages of the former, and besides gives larger yields. Some varieties, like Clyde, which are naturally light-colored and rather soft, gave surprisingly better results as regards color and firmness the past season when grown in this way. The mass of fruit on one side of the rows, fully exposed to the air and sun, was a sight worth seeing.

The wide matted row and narrow matted row are really a modification of one system. By this plan the plants are set some three and one-half or four feet wide by one and one-half feet in the rows. No runners are allowed to grow until the parent plant has become well established, and then all or a limited number of runners, according to the wide or narrow row system, are allowed to root. The general tendency of this system is to grow vines at the expense of the fruit. Large yields are sometimes obtained, but generally of smaller and poorer fruit.

Whatever the system adopted, or the character of the soil on which the plants are grown, it is of the utmost importance to start with plants of unimpaired vigor, and keep them thus. Feed liberally, and spray with Bordeaux mixture occasionally. Cultivate frequently. Experiment, and study the varieties and adaptation to soil.

Marketing Apples in Boxes.

A feeling has been steadily gaining ground among the growers of good apples that some package smaller and neater than the common barrel should be used in marketing the fruit. It seems unnecessary to here review all the considerations which have influenced fruit growers in coming to this conclusion. There are many things to be said in favor of smaller packages. There are also some few objections and many qualifications to be made. The movement toward the use of boxes has been emphasized during the shipping season of 1903 by the great scarcity and unreasonably high price of barrels. Inquiries regarding the use of boxes have accordingly been frequent; and on this account it has been thought that a brief note of our experience in the department of horticulture would prove of general interest.

Bushel boxes of two common patterns have been used during the two shipping seasons of 1902 and 1903, though not in large numbers. Both early apples and winter varieties were shipped in these packages. In every case the results were gratifying. The apples always brought as much money, or more, than the same quantity of fruit in barrels; in fact, the cash returns were nearly always greater, and sometimes surprisingly so. In one instance, in 1902, Gravensteins were shipped both in barrels and in bushel boxes on the same day and to the same dealer, the fruit being from the same trees, and graded precisely the same throughout; the apples in boxes, however, were wrapped in papers. In this instance the barrels sold at $2 each, and the boxes at the same price. Since the boxes hold very nearly one-third of a barrel, the price was approximately three times as much for the fruit in boxes.

This case, however, is extreme; no such greatly disproportionate price was secured in any other instance for box apples. Still, every shipment of apples in boxes showed a fair margin in favor of the package, and several times the difference was a handsome one.

According to our experience, it seems that the bushel box is especially advantageous for early apples, — say up to the end of the Gravenstein season. Fancy grades of all varieties, however, may be expected to show good results in boxes. Sutton Beauty, shipped as late as Christmas time, realized high prices.

Our experience also favors the use of wrapping papers on fancy apples, more especially on highly colored and on soft-fleshed early varieties. These papers are best bought ready cut for the purpose, and are supplied by various dealers.

There are several forms of boxes in use. Those which we have specially examined are as follows: —

The vegetable box in use throughout the State for potatoes, beets and similar garden truck has been considerably tested for apples. We have used it ourselves to some extent, but do not consider it suitable. This box is 18 inches square and 8 inches deep, thus having a capacity of 2,592 cubic inches, or considerably more than a standard bushel (United States standard bushel contains 2,150.42 cubic inches). The ends of this box are of $\frac{3}{4}$-inch lumber, and the sides, top and bottom of $\frac{1}{2}$-inch stuff.

The box most used and recommended by large apple shippers is represented in our collection by samples bought from a New York manufacturer. This is the box which we have chiefly used, and which we prefer. The inside dimensions are 10 by 11 by 20 inches, thus giving a capacity of 2,200 cubic inches, — very nearly the exact measure of the standard bushel. It weighs a trifle over 50 pounds, filled. The ends are of $\frac{7}{8}$-inch stuff, and the sides, top and bottom of $\frac{1}{4}$-inch stuff. It will be seen that the sides, top and bottom are very light, thus allowing a considerable spring. There is a difference of opinion among shippers as to whether this elasticity is desirable, or objectionable. Some favor it strongly; others insist that a perfectly rigid box is better. Our own opinion is that the rigid box is better for long shipments, as, for example, to Europe; but that the box with plenty of spring is better for near-by markets.

Another box, having exactly the same interior dimensions, is manufactured in Wisconsin, and is represented in our collection by a sample. We have not used this box, but are pleased with its appearance. It is better made and more attractive than the New York box, just described. The ends are of $\frac{7}{8}$-inch stuff, the top and bottom are of $\frac{1}{4}$-inch stuff, and on the sides at each corner is a strip of $\frac{3}{8}$-inch lumber, about $2\frac{1}{2}$ inches wide. This holds in place a sheet of thin veneer, which forms the principal portion of the side. The box is light and strong, as well as good looking.

These boxes can all be bought in the knock-down, and made up at home. The price is about $15 per hundred.

Another box, used in Ontario, Can., is very well made and attractive, but too expensive for the domestic trade. It measures $10\frac{1}{2}$ by $11\frac{1}{2}$ by 22 inches inside, giving a capacity of $2,656\frac{1}{2}$ cubic inches, or considerably over a bushel, — in fact, more nearly five pecks. This box is made with ends of $\frac{1}{2}$-inch lumber, sides, top and bottom of $\frac{3}{8}$-inch wood, the whole being firmly dovetailed at the corners. It forms a fine package for the foreign trade, though it is larger and more expensive than necessary.

We would not recommend any one to undertake the use of the bushel box for apples on a large scale without considerable preliminary experiment; but we consider it well worth trying. We shall be glad to answer any inquiries on this subject, so far as our experience and information allow.

Notes on Quinces.

One of the most profitable crops during the last two years on the farm of the horticultural department has been furnished by the quince orchard. This consists of about 250 trees, of all sizes, ages and varieties. The larger part of them are growing on a springy slope at the base of a hill. The soil is good, rich alluvium, excellent for garden crops when dry enough. The particular spot where these trees stand has been partially drained by tile some time ago, but these drains have now become so much clogged that the land is quite wet during a considerable part of the year.

Under these conditions the plantation gave an abundant crop of very fine fruit in 1902, and a very fair crop of nearly as good quality in 1903. These were sold mostly at wholesale, — that is, to market men and dealers, or through commission men in Boston, Worcester and Springfield.

In 1902 the No. 1 fruit, which constituted by far the bulk of the crop, sold for $2 a bushel. In most cases this price was received for the fruit *f. o. b.* at Amherst, though that shipped on commission to the three cities named sold for $2 in those markets, and charges had to be deducted. The No. 2 fruit sold for 75 cents, $1, $1.25 and $1.50 a bushel, averaging about $1.25.

In 1903 quinces were very scarce, but at the same time the crop on the trees was not so large nor of quite such good quality. The No. 1 fruit brought $2 and $2.25 (mostly the latter figure), net. The No. 2 fruit brought various prices, averaging about $1.25.

In both years the profit from the trees was considered very satisfactory. The good prices secured were attributed largely to the method of marketing the fruit. In the first place, it was well ripened; the fruit was allowed to remain on the trees until it had attained a bright, rich color. In the second place, it was very rigidly graded, only prime specimens being put into the first grade. Next, each specimen was carefully wrapped in clean fruit paper, specially cut for the purpose. These fruits were then packed in fresh, clean, attractive bushel boxes. A few were sold, some wrapped and some unwrapped, in 16-quart peach baskets, but the box was thought to be much the better package.

The use of the bushel box, or some similar small package, and the wrapping, are thought to be essential points in marketing fancy quinces, except when the fruit is delivered direct to the consumer. Quinces bruise very easily, and even the slightest bruise on a ripe quince quickly becomes discolored, and the fruit presents a highly unattractive appearance. Quinces packed in barrels and shipped some distance to market come out with nearly every specimen bruised; but the wrapping and the small package both prevent such injury.

The small package is desirable on another account, namely, because very few customers care for more than a bushel of quinces at a time; even market men with a very fair trade prefer to buy in bushel lots.

The character of the soil on which the college quince trees grow has been mentioned. Wet clay land is frequently recommended for quinces, but the trees do better on well-drained soil. Even fairly light loam will sometimes support thrifty trees for some years, though the ideal soil is moderately heavy clay. Light and sandy soils give small prospect of success.

The quince tree grows slowly, and does not require rigorous pruning. If only reasonable and seasonable attention is given to keep the head open and well balanced, nature will do the rest.

No diseases or insects of any consequence have troubled us. The trees have been sprayed with Bordeaux mixture, and this has probably helped to hold in check the scab, a fungous disease which attacks the leaves and fruit to some extent nearly every year, but which, with us, does not assume serious proportions.

The principal varieties grown are Orange, Champion and Rea (Rea's Mammoth). All succeed perfectly, and we have found them all equally acceptable in the market.

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OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

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APPROVED BY

THE STATE BOARD OF PUBLICATION.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

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GEORGE E. STONE, PH.D.,	*Botanist.*
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GEORGE W. PATCH,	*Observer.*

The co-operation and assistance of farmers, fruit-growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

The following bulletins and reports are still in stock, and can be furnished on demand: —

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 57. Fertilizer analyses.
No. 64. Analyses of concentrated feed stuffs.

No. 67. Grass thrips; treatment for thrips in greenhouses.
No. 68. Fertilizer analyses.
No. 75. Fertilizer analyses.
No. 76. The imported elm-leaf beetle.
No. 77. Fertilizer analyses.
No. 79. Growing China asters.
No. 81. Fertilizer analyses; treatment of barnyard manure with absorbents; trade values of fertilizing ingredients.
No. 82. Orchard management; cover crops in orchards; pruning of orchards; report on fruits.
No. 83. Fertilizer analyses.
No. 84. Fertilizer analyses.
No. 86. Orchard treatment for the San José scale.
No. 87. Cucumbers under glass.
No. 89. Fertilizer analyses; ash analyses of plants; instructions regarding sampling of materials to be forwarded for analysis.
No. 90. Fertilizer analyses.
No. 91. Injuries to shade trees from electricity.
No. 92. Fertilizer analyses.
No. 93. Concentrated feeds.
No. 95. Fertilizer analyses; notes on barnyard manure; trade values of fertilizing ingredients.
No. 96. Fungicides; insecticides; spraying calendar.
No. 97. A farm wood lot.
No. 98. Inspection of concentrates.
No. 99. Dried molasses beet pulp; the nutrition of horses.
No. 100. Fertilizer analyses; market values of fertilizing ingredients.
No. 101. Inspection of concentrates.
Special bulletin, — The coccid genera Chionaspis and Hemichionaspis.
Technical bulletin, No. 1, — Greenhouse Aleyrodes; strawberry Aleyrodes.
Technical bulletin, No. 2, — The graft union.
Index, 1888–95.
Annual reports for 1897, 1898, 1899, 1900, 1901, 1902, 1903, 1904.

Of the other bulletins, a few copies remain, which can be supplied only to complete sets for libraries.

ANNUAL REPORT

Of George F. Mills, *Treasurer* of the Hatch Experiment Station of Massachusetts Agricultural College,

For the Year ending June 30, 1904.

Cash received from United States Treasurer,		$15,000 00
Cash paid for salaries,	$6,012 05	
for labor,	3,070 03	
for publications,	1,017 89	
for postage and stationery,	297 42	
for freight and express,	116 30	
for heat, light, water and power,	477 95	
for chemical supplies,	25 40	
for seeds, plants and sundry supplies,	408 19	
for fertilizers,	1,331 20	
for feeding stuffs,	401 28	
for library,	31 70	
for tools, implements and machinery,	221 33	
for furniture and fixtures,	509 31	
for scientific apparatus,	318 21	
for live stock,	313 50	
for travelling expenses,	137 02	
for contingent expenses,	10 00	
for building and repairs,	301 22	
		$15,000 00

Cash received from State Treasurer,	$13,000 00	
from fertilizer fees,	4,204 58	
from farm products,	2,714 79	
from miscellaneous sources,	3,606 92	
Balance June 30, 1903,	3,198 56	
		$26,724 85
Cash paid for salaries,	$13,134 20	
for labor,	1,985 23	
Amount carried forward,	$15,119 43	

Amount brought forward,	$15,119 43	
Cash paid for publications,	1,415 18	
for postage and stationery,	551 11	
for freight and express,	161 96	
for heat, light, water and power,	405 88	
for chemical supplies,	450 71	
for seeds, plants and sundry supplies,	321 52	
for fertilizers,	3 70	
for feeding stuffs,	840 60	
for library,	215 80	
for tools, implements and machinery,	100 34	
for furniture and fixtures,	340 15	
for scientific apparatus,	952 56	
for live stock,	375 75	
for travelling expenses,	1,757 08	
for buildings and repairs,	329 53	
Balance,	3,383 55	
		$26,724 85

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ended June 30, 1904; that I have found the same well kept and classified as above; that the receipts for the year from the Treasurer of the United States are shown to have been $15,000, and the corresponding disbursements $15,000; for all of which proper vouchers are on file and have been by me examined and found correct, thus leaving no balance of the $15,000; and that $3,383.55 are left of the State appropriation and of funds received from miscellaneous sources.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 15, 1904.

REPORT OF THE BOTANIST.

G. E. STONE, N. F. MONAHAN, ASSISTANT.

With the exception of a continual increase in our correspondence, the same routine has been pursued as in previous years. Experiments have been carried on in the greenhouse as usual on problems connected with roses, carnations, tomatoes, melons and violets. There are obscure diseases connected with these crops, which are in need of further study in order to throw more light on some practical methods of controlling or eliminating them.

Work has been continued on the effects of illuminating gas on trees, — a subject which is becoming important to communities. This matter is receiving attention in various States, on account of the not infrequent destruction of avenues of valuable shade trees. Experiments of various kinds pertaining to electricity and plant life in general have also received some attention. There is an increased interest in this subject, more particularly relating to the injurious effects which are too frequently manifested in valuable shade trees coming in contact with live wires. The department has also given considerable attention to the study of soil organisms, but this work at present is merely in a preliminary stage.

Crops as related to Weather Conditions.

Every season is distinctly peculiar as regards the prevalence or non-prevalence of specific fungous growths. The early potato blight appeared in most places to do more injury than usual during the early part of the summer. This is true even where crops were sprayed. As far as this season's results are concerned, it would indicate that spraying was not commenced early enough for controlling this blight.

Most potatoes ought to have been sprayed as early as June 12 or 15, in order to check the blight, or, in other words, when they were less than one-third grown. In regard to the mildew and wet rot on the potatoes, the effects were severe in some localities, and much loss was experienced.

The asparagus rust was more pronounced than last season. A stem rot caused much damage to cultivated dandelions, — a trouble which appears to be an unusual one in this State. Cucumber and melon blight have been exceedingly rare the past summer, being the first for about six years when no trouble has been experienced. The downy mildew (*Plasmopara Cubensis*, (B. and C.) Humphrey) of cucumbers and melons, which is believed to work its way north from the south each year, did not meet our attention once during the season. On the other hand, Alternaria and Anthracnose have existed here and there, but did no appreciable harm.

The worst injuries were due to winter-killing. In our last report we alluded briefly to disastrous effects of winter-killing of various shrubs and plants, caused by the unusual prolonged fall of 1902, and the severe and sudden cold occurring in December of that year. The winter of 1903 and 1904 was even more severe than the preceding one in causing injury to plants, and this injury showed itself in a different manner. Last winter was particularly characterized as causing severe injury to native plants, as well as exotic ornamentals. The effect of the extreme cold on plants was, moreover, quite different in the winter preceding, inasmuch as in 1902 and 1903 freezing of the tender wood above ground largely took place, while the effects of last winter's freeze extended both above and below the surface of the ground. The most characteristic feature of the last winter-killing was the injury done to the roots. This was particularly noticeable on apple, pear and plum trees, and the white pine suffered to a considerable extent in some localities. Many ornamental shrubs and vines also show the same characteristic effects of root killing. Numerous apple trees were killed outright, and thousands lost a greater or less number of limbs, due to an inadequate root system to supply them. Pear trees did not seem to be affected so extensively as the apple. We observed pear trees which had their trunks split open two or three inches by the frost. The crevices eventually closed and commenced to heal over in the spring, although the effects of partial root killing have left many of them in a bad condition. The splitting of the stem is what is termed sun scald or frost crack, and the frost and sun are believed to be responsible for it. One of the characteristic results of partial root killing is that the trees will bear leaves in the spring and appear normal for a while, when suddenly the leaves commence to turn yellow and brown, and finally dry up and drop off. If only part of the root system is injured, the effects will show only on one or more branches or limbs ; but when a large portion of the root system is involved, the whole tree is likely to collapse. The development of the leaves of many apple trees, and in some instances of peach and plum trees which had partially leaved out, was suddenly arrested, and they remained in this condition all summer.

White pines in some localities appeared to be injured extensively by cold, and such native species as the white ash, red and sugar maples, birches and poplars showed the effects of the severe winter. The red maples exhibited in many cases a scarcity of foliage, especially near the top ; and more dead wood than usual was observed in some of the other species noted. The effects of root killing show more conspicuously when the soil moisture becomes reduced, and in many cases not until the season had become quite advanced did some trees show the effects of winter-killing. The effects on exotic plants were more severe than in 1902, since, in addition to the part above ground, the roots were injured.

Japanese maples, Japanese clematis, California privet, deutzia, roses, barberries, viburnums, etc., suffered to a considerable extent, and many were killed outright. This list could be greatly extended, and if complete would far exceed that noted in our last report. Sycamore and Norway maples have suffered from the loss of new wood during the past two years, as shown by the death of terminal branches. Grape vine roots were affected in many cases, and in some instances the maturing fruit wilted and dried up as if affected by the black rot.

On the whole, the season can be characterized as showing an unusual amount of winter-killing; in fact, more than has been seen for many years in this State.

TESTING OF SEED.

This department has frequently been called upon to do more or less of this work for farmers, and in many instances for seedsmen. Practically all seedsmen test their own seed; when, however, there is some doubt as to the germinating capacity, it occasionally becomes necessary to submit the seeds to a third party for results; in such cases the station is called upon to make tests. During the past year 120 samples have been tested for farmers and seedsmen.

THE PRACTICE OF SOIL STERILIZATION.

The application of steam under more or less high pressure to greenhouse soils contaminated with sterile fungi, and the use of hot water for partial sterilization, have been practised for a few years by greenhouse growers. We have had considerable experience with growing crops in sterilized soil, and some greenhouse growers have annually resorted to this method of treatment. It is our purpose to give a résumé of the results obtained from this practice.

Sterilization has been the means of lessening the amount of infection in lettuce houses in plants affected with drop and Rhizoctonia, and also of ridding houses of eel worms. It has also been the means of greatly stimulating the growth of crops; and in this respect it is likely to do as much harm as good, when intelligent supervision is not given to the crop. Some greenhouse men have resorted to sterilization for no other purpose than merely to try it, their houses being free from any infection for which this method of treatment could be recommended; while others have followed the practice of sterilizing for the purpose of modifying the growth and texture of their plants.

Besides the desired effect upon the eradication of drop and Rhizoctonia in lettuce houses, it has been the means of modifying to a large extent the texture of lettuce, and it has been employed as a stimulator. It has also been successful in eradicating troublesome insect pests. Its principal drawbacks, however, in growing lettuce, have been due to its stimulating effects on the plant itself, which, where proper precautions are not taken as regards temperature, etc., result in developing a more tender plant, with a loose and less desirable head. A lettuce plant of this type is more tender because it contains more water, and it is not so desirable for the market. Moreover, such plants are inclined to be susceptible to Botrytis rot, if not properly handled. We learned very early in our experiments that, on account of the stimulating effect brought about by growing plants in sterilized soils, it is necessary to hold the crop back by maintaining lower night temperatures. If a temperature of from 8° to 10° F. lower than is customary at night is maintained, so that the crop may develop no faster than one grown under normal conditions, the result will be a crop possessing firm heads of equal texture and resisting qualities to that grown under normal conditions. We have repeatedly called attention to the necessity of this practice in growing lettuce in sterilized soils, but this advice has not always been followed.

There has been a slight increased tendency for lettuce plants to become more subject to Botrytis rot when grown in either sterilized soil or that treated by hot water, owing to a more accelerated growth, and the production of a head of less firm texture. Botrytis rot is the principal disease that most lettuce crops are troubled with at the present time. However, it is not a very serious one with good growers. There will be observed here and there a plant affected with Botrytis rot in the best of houses; the ideal conditions, however, require that there should be none. As to the loss by Botrytis rot by experienced growers, it is of no practical importance, since the percentage will be represented by a small decimal. Botrytis rot can, nevertheless, be eliminated to a greater extent than it is, if lettuce growers would follow certain precautions more carefully. In growing plants in sterilized soil, Botrytis rot can be reduced by paying attention to proper temperature conditions at night, or, in other words, by holding the crop within legitimate limits. The principal sources of Botrytis infection are inferior prickers or seedlings. All prickers showing the black root should be discarded, as this is the beginning of the Botrytis rot. No prickers showing any injuries to the leaves, roots or cotyledons should be utilized, nor should any dead leaves be allowed to form on the plants or be left on them after transplanting. A strict adherence to the above precautions will greatly reduce Botrytis rot.

Another feature which should be considered in connection with the Botrytis rot, as well as rots in general, is watering. Lettuce growers have developed the tendency to do less watering after the crop is set than formerly. They apply most of the water previous to planting, at the present time. This practice induces the plant to develop a better root system. The surface of the soil becomes dry and remains so, which constitutes a great feature in eliminating Botrytis rot, drop, etc. Were it possible for air and sun to obtain access to a lettuce stem, there would scarcely be known such a thing as lettuce rot, with the present skill developed in handling this crop. Some growers have practised for some time the method of thoroughly wetting the soil before planting, and not applying any water after transplanting; while others water occasionally for only two or three weeks after transplanting. We demonstrated quite early in our work the importance of keeping the surface of the soil dry. Subirrigation methods reduce the rots to a considerable extent; and the method of thoroughly wetting the soil previous to planting, and not supplying any water afterwards, is similar in its effects to subirrigation, besides having the advantage of being a much cheaper method. Top coatings of clean, dry sand and other substances have similar effects in reducing rots.

We believe that a great deal can be accomplished in eliminating Botrytis rot and other diseases if more care be taken in selecting seed of a more uniform size and character. Care should be taken in selecting seed that will produce more hardy plants, and that which will produce plants less subject to infection. There is a chance for experimentation and more careful study here.

In one instance we have heard it implied that lettuce crops grown in sterilized soil were prone to mildew. This may result to some extent when the crop is not properly handled; but mildew is confined to the houses of only a very few commercial growers, and its existence in a house at all can be accounted for otherwise. We introduced the mildew into our house several times, but it always died out, and was never known to live through the summer. On the whole, far better lettuce crops are turned out to-day than five years ago, and there is a decided decrease in the amount of infection, due to the application of improved methods of treatment and culture.

As regards the effects of sterilized soil on the growth of cucumbers, our experiments and those of others have shown favorable results, since cucumbers will stand a considerable amount of forcing without any detriment; and we have none of the drawbacks due to excessive stimulation of the crop, such as we find in lettuce. When cucumbers are grown under single lights of glass, or under favorable conditions as regards light, the stimulating effects due to sterilization act most advantageously; while, on the other hand, where the crop is grown under exceedingly abnormal conditions as regards heat, light and moisture, as it sometimes is, no appreciable results are noticeable, except in so far as the treatment eliminates undesirable pests from the soil. Indeed, no form of stimulation is of any practical value to plants when their conditions of growth are extremely abnormal. Sterilization is especially efficacious in destroying eel worms and preventing timber rot, and also destroys some insect pests which trouble the cucumber. One of the special advantages in growing cucumbers in sterilized soil is connected with the seed and seedling, since germination of the seeds is hastened, the plants are accelerated, and damping-off is prevented. A considerable amount of acceleration is given to the growth of the seedling; and in our experiments, where seeds were sown in sterilized and unsterilized soil, we obtained an increase in the actual germination of the seed equal to 33 per cent. in favor of sterilized soil. The expense of sowing seeds and starting seedlings in sterilized soil would be slight, and the results obtained render this process especially desirable.

The growing of carnations in sterilized soil, according to our limited experiments, shows a slightly beneficial effect on the plant, although others who have had more extensive experience have noted very little difference as the result of this practice. It is especially applicable to carnations in eliminating the wet stem rot caused by the fungus Rhizoctonia. In our opinion, there is little reason to believe that sterilizing would succeed in preventing the dry rot caused by Fusarium. With carnations, soil sterilization possesses some advantage in the cutting bed where cuttings are affected with Rhizoctonia and the damping-off fungus (*Pythium De Baryanum*, Hesse). In our rather extensive use of sterilized soil we have never observed any detrimental influence on the soil itself; we have, however, always made use of a tolerably rich soil, well supplied with organic matter.

The principal forms of appliances now used for this purpose are similar, with some modifications, to those which have been employed for five or six years. Perforated iron pipes made up into frames, 10 to 12 feet long and 8 to 10 feet wide, are most generally used. The harrow form of apparatus, known as the Sargent sterilizer, is also largely used, and consists of an iron frame, 4 or 5 by 8 or 10 feet, provided with perforated teeth about 10 or 12 inches apart and 1 foot long. The teeth are thrust into the soil, and the steam is turned on. With this form of apparatus it is not necessary to shovel the soil, hence the process is cheap. The latter type requires a high pressure of steam, and not so great a volume; while the former apparatus requires a large volume of steam, and can be operated to advantage with 15 or 20 pounds of steam pressure.

THE INFLUENCE OF ELECTRICAL POTENTIAL ON THE GROWTH OF PLANTS.[1]

In our last report we gave results of experiments showing the effects of current electricity upon the growth of plants, also the results of subjecting plants and moist seeds to different electrical potentials. We shall give here the results of further experiments along similar lines, and present some results relating to differences of electrical potential which exist between locations in trees and corresponding situations more or less removed from them.

---

[1] These experiments were conducted by N. F. Monahan.

In the first series of experiments we will consider the influence of electrical potential upon growth. In subjecting plants to an atmospheric charge of a certain potential we used a glass case such as is described in our preceding report, being, briefly, a glass case 3 feet 4 inches long, 2 feet 9 inches wide and 2 feet 11 inches high, with shellacked wooden frames and bottom. Another case, for comparison, and similar in structure but slightly larger, was also employed. Both cases were tolerably tight when closed, and were placed on movable trucks, from which they were well insulated, in a large greenhouse. The greenhouse screened out, as it were, the atmospheric electricity. At no time have we ever been able to detect any electrical potential in the air in greenhouses. The soil used in growing the plants was of uniform type, very carefully mixed; in fact, every precaution was taken to have the soil conditions the same in each case, and all its various constituents were thoroughly incorporated.

In the case which was to be treated was placed a small water-dripping apparatus, which served as a collector, and which indicated the degree of charging. The air was charged by means of a wire projecting into the case from a Topler-Holtz influence machine. All electrical readings were measured by a Thompson quadrant electrometer.

In the two experiments now described radish plants were employed, as they seemed to be most suitable for the condition under which they were grown. The seeds were of a uniform grade, and were sown in rows 3 inches apart and 1 inch apart in the rows. It was the intention to charge the case each morning to a potential of 150 volts; but this was impossible, as exactly 150 volts could not always be obtained, and at times, on account of the dampness of the air, no charge could be procured from the machine. The doors of both cases were kept closed for four hours after the charge had been induced into the treated case, and at the end of that time they were opened; therefore, for twenty out of every twenty-four hours all the plants were growing under the same conditions. At all times the conditions of temperature and moisture were practically the same in both charged and normal, or uncharged, cases.

TABLE I., EXPERIMENT I. (*Raphanus sativus* L.). — *Showing the Results obtained by electrically charging the Air in a Case.*

CASE.	Average Daily Charge (Volts).	Number of Plants.	TOTAL WEIGHT IN GRAMS OF —	
			Tops.	Roots.
Normal case, ...	–	219	2,211.3	510.3
Electrically charged case, .	167.2	162	2,551.5	623.7

TABLE I., EXPERIMENT I. (*Raphanus sativus* L.). — *Showing the Results obtained by electrically charging the Air in a Case* — Concluded.

CASE.	AVERAGE WEIGHT IN GRAMS OF —		PER CENT. GAINED IN WEIGHT OF —		Total Per Cent. gained.
	Tops.	Roots.	Tops.	Roots.	
Normal case, . . .	10.097	2.333	–	–	–
Electrically charged case,	15.750	3.850	55.98	65.67	57.67

The experiment in Table II. is similar to Experiment I., except that the seeds were planted in rows 5 inches apart, instead of 4, as in the preceding one. The cold weather interfered with the development of the plants, and the experiment was brought to a close earlier than was planned.

TABLE II., EXPERIMENT II. (*Raphanus sativus* L.). — *Showing the Results obtained by electrically charging the Air in a Case.*

CASE.	Average Daily Charge (Volts).	Number of Plants.	TOTAL WEIGHT IN GRAMS OF —	
			Tops.	Roots.
Normal case, ...	–	136	91	98.5
Electrically charged case, .	141.2	69	66	74.0

TABLE II., EXPERIMENT II. (*Raphanus sativus* L.). — *Showing the Results obtained by electrically charging the Air in a Case* — Concluded.

CASE.	AVERAGE WEIGHT IN GRAMS OF —		PER CENT. GAINED IN WEIGHT OF —		Total Per Cent. gained.
	Tops.	Roots.	Tops.	Roots.	
Normal case, . . .	.669	.724	-	-	-
Electrically charged case,	.955	1.072	42.73	49.46	45.58

The results given in tables I. and II. are quite similar. In Table I. there was a gain of 55.98 per cent. in the weight of tops or leaves and 65.67 per cent. in the weight of roots, over the uncharged plants; in Table II., the percentage given for the tops is 42.73 and for the roots 49.46. The total gain in Experiment I. is 57.67 per cent.; in Experiment II. it is 45.58 per cent. The average gain in both experiments was 49.35 per cent. for the tops or leaves, 57.56 per cent. for the roots and 51.62 per cent. as an average total gain for the electrically stimulated plants. The charge in Experiment I. averaged 167.2 volts; in Experiment II., 141.2 volts. The charge only lasted a few seconds in all instances, and practically disappeared from the atmosphere of the case in fifteen minutes.

Some measurements were occasionally made of a dozen typical plants from each case in Experiment I. The object in taking these measurements was, first, to show the difference in size and degree of acceleration, differentiation, etc., of the treated and untreated plants; and, second, to compare the electrically treated plants with those that were not treated, when the latter were practically in the same stage of development; or, in other words, the plants in the electrically charged case were compared with those in the untreated case on the day in which the measurements were made, and also five days later, when the development of the normal plants had reached practically the same stage as that of the plants in the electrically treated case. By this method any changes in the external configuration of the plants brought about by electrical stimulation could be noted.

Table III. shows the results of these measurements, and Table IV. gives a comparison between the leaves of the plants in the charged and uncharged cases, measurements being made August 15 and August 20, respectively.

TABLE III. — *Showing the Average of Some Measurements of Plants in Table I., Experiment I.*

Date.	CASE.	Width of Leaf (Centimeters).	Length of Blade (Centimeters).	Length of Petiole (Centimeters).	Length of Whole Leaf (Centimeters).
August 15,	Normal case, . . .	2.13	4.17	2.28	6.49
	Electrically charged case, .	2.66	5.33	4.34	10.16
	Difference, . . .	.53	1.16	2.06	3.67
August 20,	Normal case, . . .	2.79	4.83	3.35	8.10
	Electrically charged case, .	3.65	6.95	5.20	12.05
	Difference, . . .	.86	2.12	1.85	3.95

TABLE IV. — *Giving a Comparison between the Leaves of the Plants in the Charged and Uncharged Cases.*

Date.	CASE.	Width of Leaf (Centimeters).	Length of Blade (Centimeters).	Length of Petiole (Centimeters).	Length of Whole Leaf (Centimeters).
August 20,	Normal case, . . .	2.79	4.83	3.35	8.10
August 15,	Electrically charged case,	2.66	5.33	4.34	10.16
	Difference, . . .	.13	.50	.99	2.06

The results of these experiments show what was readily discernible with the naked eye; namely, that the length of leaves of the electrically treated plants was quite different from those of the normal or untreated plants, and that the width and length of the leaf blade and the length of the petioles of the plants in the electrically treated case exceeded those of the normal or untreated plants. When comparisons, however, are made of the plants in the electrically treated case of August 15 with those of the normal of August 20, or five days later, it will be observed that the width of the blade of the normal exceeded that of the treated one by .13 centimeters, and that the difference in the length of the blades, petioles and leaves in general was much less marked. The length of the blade, petiole and whole leaf in general was longer for identical periods of development in the electrically treated plants than in the normal or untreated, although the width of the blade was more generally marked in its development in the normal than in the plants in the electrically charged case. The morphological differentiation due to electrical stimulation is shown in these experiments.

The plants in the electrically charged case were of a lighter-green color, and they showed a greater tendency to leaf burn than did the normal plants. They also appeared to be more succulent, but moisture determinations made of the leaves at the close of the experiment showed no difference in this respect. The roots in the treated case were relatively more elongated than those in the untreated case. Whether this form of electrical treatment stimulates plants more than current electricity cannot definitely be determined, from the lack of a sufficient number of comparative results. However, these two experiments would indicate, both from naked-eye observations and from weights and measurements, that static charges act as more pronounced stimuli than current electricity when applied to soils. Electrical stimulation gives rise to effects similar to those caused by lack of light, or such as result from partial etiolation. The light-green color of the foliage and the elongated organs were similar to those noticed in plants grown in poorly lighted greenhouses in winter, and in shaded plants grown in the forest. Other kinds of electrical stimulation appear to have the same general effects on the plant.

Comparison of Atmospheric Electrical Potential in Trees and in the Free Air.

The idea has been advanced that trees, shrubs, and in fact all growing plants, must form a means by which the potential of the air and the earth is held in equilibrium. A living tree does not offer such an enormous resistance to the passage of electricity as dead wood does. We have charged small plants in the laboratory to a sufficiently high potential so that, when placed in the dark, sparks were emitted from many points of the leaves, and living plants will readily take charges from a static machine. It has also been maintained that trees modify the electrical potential of the atmosphere of their immediate surroundings.

Grandeau[1] and other experimenters have shown that when plants are grown under wire netting they develop less in a given space of time than do plants grown under similar conditions in every respect as regards light, etc., in the free atmosphere. The interpretation of this phenomenon is, that wire screens modify the atmospheric electrical potential, or absorb the electricity, as it were, to the detriment of the plant. This method of experimenting with wire nets we have employed only to a limited extent, and at present have not a sufficient number of results on which to report. Unfortunately, most of the experiments previously made in this line are open to severe criticism, from the fact that too few plants were employed, and different methods of surrounding the plants with wire netting prevailed, which accounts for occasional conflicting results. Grandeau obtained similar results by growing plants under a chestnut tree, as under a wire netting; and he concluded that it is probable that trees modify to a large extent the electrical potential of the atmosphere in their immediate neighborhood. The object we had in view in these experiments was to ascertain, among other things, whether trees did modify in any way the electrical potential of the atmosphere in their immediate vicinity. In order to ascertain whether there is any discernible difference between the atmospheric electrical potential in trees and in the free air, at corresponding height and location, we made a series of three readings daily from April to July, and daily readings during the remainder of the experiment, with collectors and a Thompson quadrant electrometer. These observations were started early in the spring, before any foliage had developed, and continued until after the leaves had fallen. A collector was placed in an elm tree, at a height of 40 feet above the ground, at a fork between two limbs from which it was insulated. The collector was situated about on a level with, or slightly above, the spread of the branches and leaves. The tree, however, was not in every respect a typical elm for this region, the head being high and close, with the branches drooping but little.

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[1] "Comptes rendus," T. LXXXVII., 1878, pp. 60, 285, 939. "Chimie et Physiologie appliquées a l'Agriculture et à la Sylviculture par L. Grandeau," Paris, 1879, p. 279.

The collector in the tree is designated as II. in the following monthly records; and the one in the free air, which was located near a building, is designated as I. Collector III. was in a spruce tree, and Nos. IV. and V. were added in August. Collector III. was located 12 feet high, near the top and under the branches of a small Norway spruce. Nos. IV. and V. represent readings from two small Norway spruce trees, about 2 feet high, in pots; they were located about 16 feet from the ground, on a plank scaffold. No. IV. had a copper plate in the soil, which was connected with the electrometer when readings were made. No. V. had a similar plate, but was grounded with an insulated wire; another wire led from this copper plate in the soil to the electrometer.

Readings were taken from the various collectors on the same electrometer at practically the same time each day. Table V. shows readings taken from April 20 to Nov. 1, 1904, and where readings are omitted they could not be obtained. All readings not otherwise recorded imply negative potential.

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air.*

DATE.	9 A.M.		1 P.M.		5 P.M.	
	Collector I. — Free Air.	Collector II. — Elm.	Collector I. — Free Air.	Collector II. — Elm.	Collector I. — Free Air.	Collector II. — Elm.
1904.						
April 21, . .	56.0	56.0	32.0	32.0	0.0	0.0
22, . .	48.0	48.0	32.0	32.0	16.0	16.0
23, . .	8.0	8.0	40.0	40.0	–	–
24, . .	16.0	16.0	16.0	16.0	16.0	–
25, . .	40.0	40.0	40.0	40.0	16.0	16.0
26, . .	32.0	32.0	16.0	16.0	32.0	32.0
27, . .	–	–	60.0	60.0	40.0	40.0
28, . .	8.0	8.0	32.0	32.0	45.0	45.0
29, . .	24.0	0.0	8.0	0.0	0.0	0.0
30, . .	32.0	32.0	–	–	–	–

April 24, trees show signs of budding.

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air* — Continued.

DATE.	9 A.M.		1 P.M.		5 P.M.	
	Collector I. — Free Air.	Collector II. — Elm.	Collector I. — Free Air.	Collector II. — Elm.	Collector I. — Free Air.	Collector II. — Elm.
1904.						
May 1, . .	112.0	112.0	32.0	32.0	0.0	0.0
2, . .	16.0	16.0	12.0	12.0	8.0	8.0
3, . .	48.0	48.0	40.0	40.0	48.0	48.0
4, . .	56.0	56.0	24.0	24.0	24.0	24.0
5, . .	56.0	56.0	56.0	56.0	8.0	0.0
6, . .	12.0	12.0	24.0	24.0	20.0	20.0
7, . .	64.0	64.0	28.0	24.5	–	–
8, . .	–	–	–	–	–	–
9, . .	–	–	–	–	–	–
10, . .	24.0	24.0	28.0	28.0	–	–
11, . .	48.0	48.0	8.0	8.0	16.0	16.0
12, . .	72.0	72.0	80.0	80.0	40.0	40.0
13, . .	64.0	64.0	8.0	0.0	24.0	20.0
14, . .	16.0	14.0	–	–	–	–
15, . .	8.0	0.0	8.0	0.0	–	–
16, . .	–	–	–	–	–	–
17, . .	–	–	32.0	–	–	–
18, . .	–	–	20.0	8.0	20.0	–
19, . .	40.0	32.0	32.0	17.0	16.0	12.0
20, . .	56.0	40.0	32.0	24.0	–	–
21, . .	8.0	0.0	16.0	9.0	20.0	16.0
22, . .	32.0	16.0	–	–	–	–
23, . .	8.0	4.0	16.0	8.0	32.0	24.0
24, . .	16.0	14.0	20.0	12.0	8.0	8.0
25, . .	218.0	32.0	16.0	16.0	20.0	16.0
26, . .	88.0	56.0	32.0	0.0	–	–
27, . .	–	–	–	–	–	–
28, . .	24.0	20.0	24.0	20.0	16.0	0.0
29, . .	32.0	0.0	28.0	0.0	–	–
30, . .	–	–	–	–	–	–
31, . .	–	–	–	–	–	–

May 7, leaves beginning to show; May 9, hardly a trace; May 14, trees fairly well leaved, seeds beginning to drop; heavy thunder showers on 26th; 5 P.M. readings gave extremely high and fluctuating potentials.

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air* — Continued.

DATE.	9 A.M.		1 P.M.		5 P.M.	
	Collector I. — Free Air.	Collector II. — Elm.	Collector I. — Free Air.	Collector II. — Elm.	Collector I. — Free Air.	Collector II. — Elm.
1904.						
June 1, . .	32.0	24.0	16.0	8.0	+8.0	—8.0
2, . .	–	–	–	–	–	–
3, . .	–	–	16.0	8.0	–	–
4, . .	–	–	16.0	8.0	–	–
5, . .	8.0	0.0	8.0	0.0	112.0	56.0
6, . .	20.0	0.0	8.0	0.0	0.0	0.0
7, . .	–	–	–	–	–	–
8, . .	–	–	–	–	–	–
9, . .	–	–	–	–	–	–
10, . .	–	–	16.0	8.0	8.0	0.0
11, . .	28.0	16.0	32.0	20.0	24.0	16.0
12, . .	72.0	56.0	8.0	0.0	8.0	0.0
13, . .	40.0	24.0	40.0	24.0	–	–
14, . .	8.0	0.0	32.0	0.0	–	–
15, . .	16.0	8.0	28.0	24.0	–	–
16, . .	8.0	0.0	8.0	0.0	–	–
17, . .	16.0	8.0	40.0	24.0	–	–
18, . .	36.0	24.0	28.0	20.0	16.0	0.0
19, . .	72.0	48.0	88.0	56.0	8.0	0.0
20, . .	32.0	20.0	16.0	8.0	8.0	0.0
21, . .	20.0	16.0	16.0	8.0	8.0	0.0
22, . .	20.0	8.0	–	–	–	–
23, . .	–	–	–	–	–	–
24, . .	–	–	–	–	–	–
25, . .	–	–	–	–	–	–
26, . .	–	–	–	–	–	–
27, . .	24.0	12.0	8.0	0.0	0.0	0.0
28, . .	16.0	12.0	8.0	trace	8.0	trace
29, . .	–	–	–	–	–	–
30, . .	–	–	–	–	–	–

June 2-4, rain; June 6-9, wet wire.

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air* — Continued.

DATE.	9 A.M.		1 P.M.		5 P.M.	
	Collector I. — Free Air.	Collector II. — Elm.	Collector I. — Free Air.	Collector II. — Elm.	Collector I. — Free Air.	Collector II. — Elm.
1904.						
July 1, . .	–	–	–	–	–	–
2, . .	–	–	–	–	8.0	4.0
3, . .	–	–	–	–	–	–
4, . .	–	–	–	–	–	–
5, . .	36.0	16.0	32.0	20.0	32.0	20.0
6, . .	28.0	12.0	24.0	0.0	24.0	0.0
7, . .	88.0	56.0	8.0	0.0	8.0	0.0
8, . .	–	–	20.0	8.0	28.0	12.0
9, . .	12.0	0.0	48.0	24.0	36.0	20.0
10, . .	–	–	–	–	8.0	0.0
11, . .	24.0	8.0	24.0	0.0	24.0	0.0
12, . .	–	–	–	–	–	–
13, . .	–	–	–	–	–	–
14, . .	–	–	–	–	–	–
15, . .	–	–	–	–	–	–
16, . .	–	–	–	–	–	–
17, . .	–	–	–	–	–	–
18, . .	–	–	–	–	–	–
19, . .	12.0	0.0	8.0	0.0	8.0	trace
20, . .	12.0	trace	16.0	4.0	16.0	4.0
21, . .	16.0	trace	28.0	8.0	12.0	trace
22, . .	–	–	–	–	–	–
23, . .	–	–	–	–	–	–
24, . .	–	–	–	–	–	–
25, . .	–	–	–	–	–	–
26, . .	–	–	–	–	–	–
27, . .	–	–	–	–	–	–
28, . .	20.0	8.0	24.0	8.0	–	–
29, . .	–	–	–	–	–	–
30, . .	28.0	8.0	32.0	16.0	16.0	trace
31, . .	–	–	–	–	–	–

July 12-18, electrometer out of order; July 22-28, rain.

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air* — Continued.

[Collector III., 12 feet high, in Norway spruce. Nos. IV. and V., readings taken from copper plates in soil. Time of observation, 9 A.M.]

DATE.	Collector I. — Free Air.	Collector II. — Elm.	Collector III. — Spruce.	No. IV. — Small Spruce Tree, not grounded.	No. V. — Small Spruce Tree, grounded.
1904.					
August 1, . .	88.0	52.0	–	–	–
2, . .	0.0	0.0	–	–	–
3, . .	8.0	0.0	–	–	–
4, . .	–	–	–	–	–
5, . .	–	–	–	–	–
6, . .	72.0	40.0	–	–	–
7, . .	32.0	16.0	–	–	–
8, . .	96.0	56.0	–	–	–
9, . .	40.0	24.0	–	–	–
10, . .	8.0	0.0	–	–	–
11, . .	16.0	8.0	Very slight movement		
12, . .	56.0	32.0	+4.0	+4.0	+4.0
13, . .	8.0	trace	+trace	+trace	+trace
14, . .	96.0	56.0	+6.0	+8.0	+16.0
15, . .	24.0	16.0	+trace	+4.0	+trace
16, . .	32.0	16.0	trace	+8.0	+12.0
17, . .	0.0	0.0	+8.0	+8.0	+12.0
18, . .	+16.0	+8.0	—8.0	—8.0	—8.0
19, . .	40.0	20.0	0.0	trace	trace
20, . .	–	–	–	–	–
21, . .	72.0	40.0	+8.0	+8.0	+12.0
22, . .	8.0	+trace	+trace	+trace	+trace
23, . .	8.0	trace	+8.0	+4.0	+8.0
24, . .	48.0	24.0	0.0	trace	trace
25, . .	56.0	28.0	0.0	0.0	trace
26, . .	96.0	52.0	+8.0	+8.0	+12.0
27, . .	88.0	40.0	0.0	0.0	0.0
28, . .	40.0	24.0	0.0	0.0	0.0
29, . .	8.0	trace	0.0	0.0	0.0
30, . .	40.0	16.0	+2.0	+2.0	+2.0
31, . .	40.0	24.0	0.0	0.0	0.0

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air* — Continued.

[Collector III., 12 feet high, in Norway spruce. Nos. IV. and V., readings taken from copper plates in soil. Time of observation, 3 P.M.]

DATE.	Collector I. — Free Air.	Collector II. — Elm.	Collector III. — Spruce.	No. IV. — Small Spruce Tree, not grounded.	No. V. — Small Spruce Tree, grounded.
1904.					
August 1,	80.0	40.0	–	–	–
2,	–	–	–	–	–
3,	8.0	0.0	–	–	–
4,	–	–	–	–	–
5,	–	–	–	–	–
6,	24.0	12.0	–	–	–
7,	40.0	24.0	–	–	–
8,	88.0	56.0	–	–	–
9,	24.0	12.0	–	–	–
10,	0.0	0.0	–	–	–
11,	8.0	0.0	0.0	0.0	0.0
12,	40.0	24.0	+4.0	+4.0	+4.0
13,	56.0	4.0	+trace	+trace	+trace
14,	24.0	12.0	+4.0	+trace	+4.0
15,	72.0	40.0	+4.0	+8.0	+12.0
16,	16.0	8.0	trace	trace	trace
17,	0.0	0.0	0.0	0.0	0.0
18,	0.0	0.0	0.0	0.0	0.0
19,	40.0	20.0	0.0	0.0	trace
20,	–	–	–	–	–
21,	40.0	24.0	+4.0	trace	12.0
22,	8.0	0.0	0.0	0.0	0.0
23,	8.0	0.0	+8.0	trace	trace
24,	56.0	32.0	0.0	0.0	0.0
25,	32.0	24.0	0.0	0.0	trace
26,	72.0	40.0	+8.0	+8.0	+8.0
27,	48.0	24.0	0.0	0.0	0.0
28,	8.0	trace	0.0	0.0	0.0
29,	4.0	0.0	0.0	0.0	0.0
30,	16.0	8.0	0.0	0.0	0.0
31,	40.0	24.0	0.0	0.0	0.0

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air* — Continued.

[Collector III., 12 feet high, in Norway spruce. Nos. IV. and V., readings taken from copper plates in soil. Time of observation, 9 A.M.]

DATE.	Collector I. — Free Air.	Collector II. — Elm.	Collector III. — Spruce.	No. IV. — Small Spruce Tree, not grounded.	No. V. — Small Spruce Tree, grounded.
1904.					
September 1, .	88.0	52.0	+4.0	+4.0	+4.0
2, .	-	-	-	-	-
3, .	-	-	-	-	-
4, .	96.0	56.0	+8.0	+8.0	+8.0
5, .	72.0	40.0	4.0	2.0	4.0
6, .	—8.0	—trace	+0.0	+0.0	+0.0
7, .	40.0	24.0	0.0	0.0	0.0
8, .	56.0	32.0	0.0	0.0	0.0
9, .	72.0	40.0	0.0	trace	trace
10, .	-	-	-	-	-
11, .	-	-	-	-	-
12, .	-	-	-	-	-
13, .	-	-	-	-	-
14, .	-	-	-	-	-
15, .	-	-	-	-	-
16, .	-	-	-	-	-
17, .	-	-	-	-	-
18, .	-	-	-	-	-
19, .	-	-	-	-	-
20, .	-	-	-	-	-
21, .	-	-	-	-	-
22, .	-	-	-	-	-
23, .	-	-	-	-	-
24, .	-	-	-	-	-
25, .	-	-	-	-	-
26, .	0.0	0.0	0.0	0.0	0.0
27, .	8.0	8.0	0.0	0.0	trace
28, .	-	-	-	-	-
29, .	-	-	-	-	-
30, .	24.0	24.0	0.0	trace	trace

September 6, possibly slight movement toward positive in Nos. III., IV. and V.
Operator away from September 10 to September 25.

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air* — Concluded.

[Collector III., 12 feet high, in Norway spruce. Nos. IV. and V., readings taken from copper plates in soil. Time of observation, 9 A.M.]

DATE.	Collector I. — Free Air.	Collector II. — Elm.	Collector III. — Spruce.	No. IV. — Small Spruce Tree, not grounded.	No. V. — Small Spruce Tree, grounded.
1904.					
October 1, . .	40.0	32.0	4.0	2.0	4.0
2, . .	56.0	48.0	4.0	trace	2.0
3, . .	96.0	80.0	8.0	trace	trace
4, . .	–	–	–	–	–
5, . .	8.0	8.0	4.0	4.0	8.0
6, . .	40.0	36.0	trace	trace	trace
7, . .	–	–	–	–	–
8, . .	–	–	–	–	–
9, . .	–	–	–	–	–
10, . .	–	–	–	–	–
11, . .	–	–	–	–	–
12, . .	–	–	–	–	–
13, . .	–	–	–	–	–
14, . .	8.0	8.0	2.0	2.0	4.0
15, . .	40.0	40.0	4.0	trace	4.0
16, . .	8.0	8.0	trace	0.0	0.0
17, . .	16.0	16.0	2.0	trace	2.0
18, . .	40.0	0.0	0.0	0.0	0.0
19, . .	24.0	24.0	trace	0.0	trace
20, . .	–	–	–	–	–
21, . .	–	–	–	–	–
22, . .	–	–	–	–	–
23, . .	–	–	–	–	–
24, . .	40.0	40.0	0.0	0.0	0.0
25, . .	8.0	8.0	trace	trace	trace
26, . .	–	–	–	–	–
27, . .	–	–	–	–	–
28, . .	–	–	–	–	–
29, . .	8.0	8.0	0.0	trace	trace
30, . .	–	–	–	–	–
31, . .	–	–	–	–	–

October 5, leaves turning color, very few falling; October 20, leaves taken off by high wind; October 24, leaves entirely off trees.

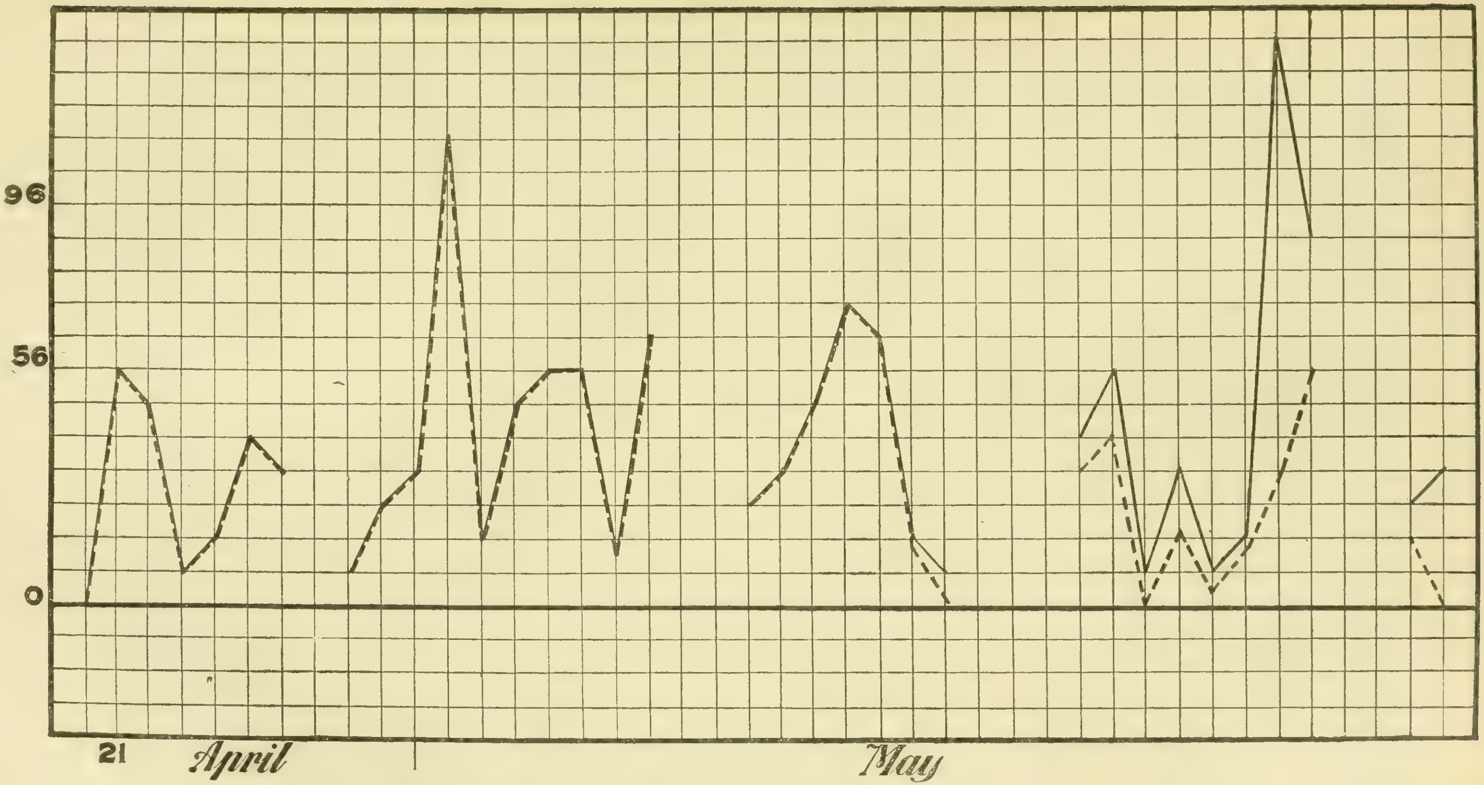

DIAGRAM I. — Showing the results of electrometer readings from free air, Collector I., and elm tree, Collector II., for the months of April and May. The spaces on the abscissa denote days; the spaces on the ordinate denote periods of eight volts each. Solid line indicates free air readings; dotted line indicates elm tree readings.

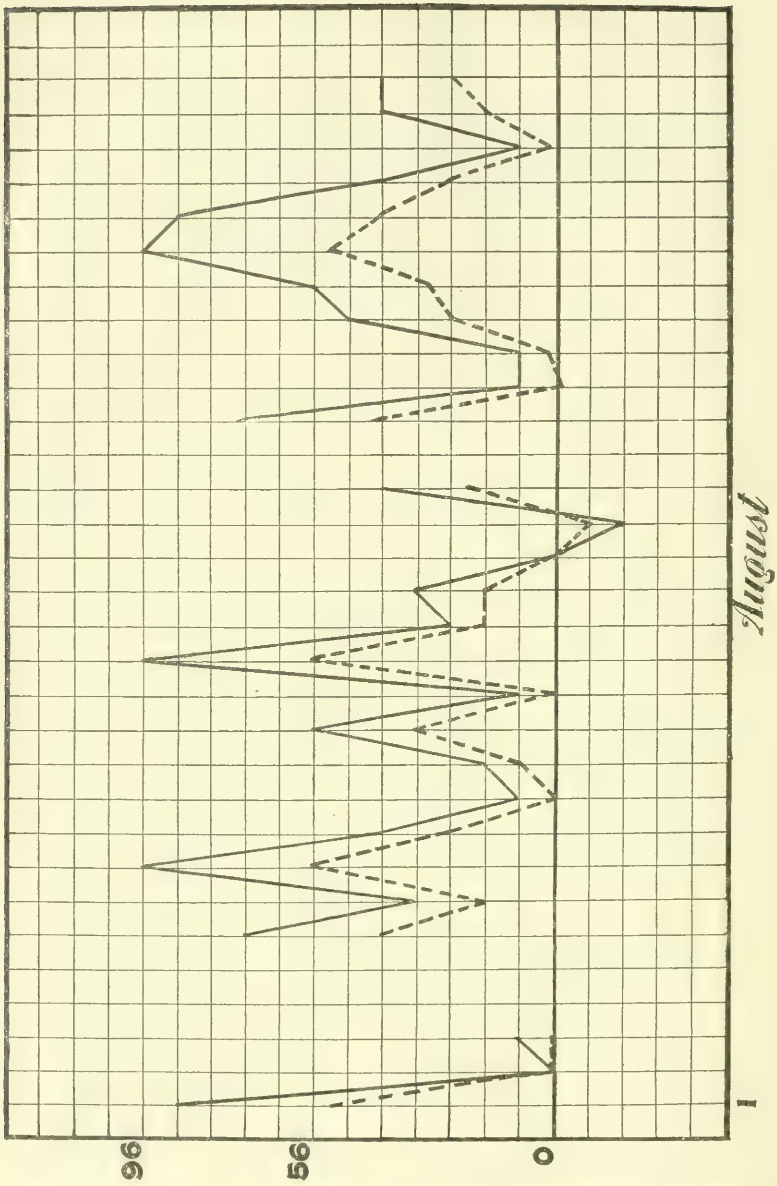

DIAGRAM II.—Showing the results of electrical readings from free air, Collector I., and elm tree, Collector II., for the month of August. The spaces on the abscissa denote days; the spaces on the ordinate denote periods of eight volts each. Solid line indicates free air readings; dotted line indicates elm tree readings.

TABLE VI. — *Summary of Potential Readings of the Preceding Tables, showing the Total and Average Results given by Collector I. (Free Air) and Collector II. (Elm Tree).*

	TOTAL VOLTAGE OF—		AVERAGE DAILY VOLTAGE OF—	
	Collector I. — Free Air.	Collector II. — Elm.	Collector I. — Free Air.	Collector II. — Elm.
April, ...	240	240	30.0	30.0
May 1 to May 14, ...	572	572	52.0	52.0
May 14 to May 31, . . .	398	228	44.2	25.3
June, ...	498	276	38.0	21.2
July, ...	224	108	37.3	18.0
August, ...	1,088	592	54.4	29.6
September, ...	456	276	57.0	34.5
October 1 to October 7, . .	240	204	48.0	40.8
October 7 to October 31, . .	152	152	19.0	19.0

While the results obtained from this series of experiments do not possess the same value as the series extending over more than one season, they nevertheless point very strongly to the conclusion that trees do modify to a considerable extent atmospheric electrical potential in their immediate vicinity. By consulting the summary, Table VI., where the total and average potentials for different periods are shown, it will be seen that some important differences occurred between the potentials of the free air and the elm tree collectors. It is significant also that there occurred no difference in the readings between the free air collector and that in the elm tree up to the time when the leaves developed. The few readings which we were able to make in October after the leaves had fallen showed the same results.

Our interpretation of the results of these observations is, that the elm tree took some electricity from the air immediately surrounding it during the period in which it was in foliage. If this single series of observations is typical of what takes place in nature, then we can conclude that the atmospheric electrical potential is not affected much by trees in the immediate vicinity except when they are in foliage. There are a few instances where collectors I. and II. showed positive potentials, and practically the same relative differences are shown here as in the numerous negative potential readings.

The collector in the branches of the spruce tree, 12 feet from the ground (Collector III.), from which it was well insulated, invariably showed the opposite potential from that obtained in the free air and from the elm tree. It will appear from this that the air surrounding the collector in the spruce tree was charged with the same kind of potential (positive or negative) as that of the earth; and the readings taken from Nos. IV. and V., which were very close to this tree, although four feet higher, gave the same kind of potential as that of Collector III., or larger spruce tree. In other words, all the potentials in Nos. III., IV. and V. are opposite to that of the air. There were some difficulties experienced in obtaining readings of the three spruce trees, — partly because the readings had to be taken too close to the ground, and partly, perhaps, because we were dealing with the same kind of potential in the air that the earth was charged with; and that, therefore, when the potential of the air in the branches of the spruce tree and the potential of the earth were the same in degree and kind, differences in potential would not exist, and therefore measurements would be impossible. Evergreen trees, which are supplied with a large number of pointed leaves, may possibly be better adapted to discharge electricity than deciduous trees. It is quite possible that evergreen trees behave quite differently from deciduous trees as regards their relationship to atmospheric electricity. In our opinion, there is a strong probability that all living plants act as conductors, or that they serve to keep the potential of the earth and the air in more or less equilibrium; and that trees and vegetation in general take part in this, although in all probability all species do not act in the same specific manner.

This phase of the subject has not been studied as much as is desirable. We infer from our own observations that some trees show a great tendency towards conducting the electricity from the air to the earth, and that other trees show the same tendency for conducting electricity from the earth to the air; and that in all probability this exchange of electricity from the air to the earth, and *vice versa*, does not take place at the same time through the same tree; and that, under normal conditions, — that is, when no great electrical disturbance is taking place, — some species of trees always conduct the electricity to the air from the earth, while other species conduct electricity from the earth to the air. It is not at all unlikely that in the vicinity of large trees there is exhibited a detrimental influence on crops, and vegetation in general, to an extent which cannot be accounted for by the lack of sunshine and soil moisture.

Some Important Literature relating to Diseases, etc., of Crops not generally believed to be caused by Fungi or Insects.

The publication by Dr. W. C. Sturgis[1] of a host index relating to economic fungi has proved of great value to students, and to those interested in the literature pertaining to fungous diseases of our important cultivated crops. Unfortunately, the host index of Dr. Sturgis does not include those troubles generally termed physiological, or those of an unknown nature.

The following list is compiled to supplement his host index to literature pertaining to fungous diseases. It is by no means complete, but includes at least some of the more important publications of the agricultural experiment stations and United States Department of Agriculture relating to functional and unknown disorders.

Apple (*Pirus malus*, L.).

Baldwin Fruit-spot, Brown-spot. — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 164, 1899, pp. 215–219. Vt. Agr. Exp. Sta., Rept. 1899; 1900, pp. 159–164.

Frost-blisters (*Leaves*). — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 220, 1902, pp. 217–224. See *Quince*. Mass. Hatch Exp. Sta., Rept. No. 15, 1903, pp. 32–34.

Frost-cracks (*Fruit*). — Vt. Agr. Exp. Sta., Bull. No. 49, 1895, p. 100. See *Pear*.

Rosette. — Col. Agr. Exp. Sta., Bull. No. 69, 1902, pp. 4–6.

Scald. — Vt. Agr. Exp. Sta., Rept. 1896–97, pp. 55–59; also 11th Rept. 1898, pp. 198, 199.

Spraying and Bloom. — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 196, 1900.

Spraying Injuries. — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 220, 1902, pp. 225–230.

Apricot (*Prunus*).

Leaf-scorch or Sunburn. — Ariz. Agr. Exp. Sta., Rept. 1898, pp. 163–165.

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[1] Conn. (State) Agr. Exp. Sta., Bull. No. 118, 1893; Repts. 17, 1893; 21, 1897; and 24, 1900.

ASTER (*Callistephus hortensis*, Cass.).

Yellows.—Mass. Hatch Exp. Sta., Bull. No. 79, 1902, p. 11.

BEET (*Beta vulgaris*, L.).

Leaf-scorch (*Sugar Beet*).—N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 162, 1899, pp. 167–171.

CAULIFLOWER (*Brassica oleracea*, L.).

Leaf-scorch or Tip-burn.—N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 162, 1899, pp. 176, 177.

CELERY (*Apium graveolens*, L.).

Pithiness.—Maryland Agr. Exp. Sta., Bull. No. 83, 1902; also Bull. No. 93, 1904.

CHERRY (*Prunus Cerasus*, L.).

Leaf-scorch.—N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 162, 1899, pp. 171–176. See *Maple*, etc.

COTTON (*Gossypium*, spp.).

Red Leaf-blight.—Ala. Coll. Sta., Bull. No. 36, 1892, pp. 31, 32.

Shedding of Bolls.—Ala. Coll. Sta., Bull. No. 41, 1892, pp. 50–53.

Yellow Leaf-blight.—Ala. Coll. Sta., Bull. No. 36, 1892, pp. 2–31.

CUCUMBER (*Cucumis sativus*, L.).

Leaf-curl.—Mass. Hatch Exp. Sta., Bull. No. 87, pp. 30, 31.

Stem-curl.—Mass. Hatch Exp. Sta., Bull. No. 87, p. 32.

Wilt.—Mass. Hatch Exp. Sta., Bull. No. 87, p. 32; also Rept. 1899, pp. 159-163.

GRAPE (*Vitis*, spp.).

California Vine Disease.—U. S. Dept. Agr., Div. Veg. Path., Bull. No. 2, 1892. U. S. Dept. Agr., Farmers' Bull. No. 30, pp. 1–11.

Chlorosis.—U. S. Dept. Agr., Div. Veg. Path., Bull. No. 2, 1892, pp. 179–181.

Coulure.—U. S. Dept. Agr., Div. Veg. Path., Farmers' Bull. No. 30, pp. 11–14.

Mal Nero, Rougeot and Folletage.—N. Y. (Cornell Univ.) Agr. Exp. Sta., Bull. No. 76, 1894, pp. 420, 421. U. S. Dept. Agr., Div. Veg. Path., Bull. No. 2, 1892, pp. 181–198.

Sunstroke.—Cal. Agr. Exp. Sta., Rept. 1887–93, pp. 450, 451.

Pourriture.—U. S. Dept. Agr., Div. Veg. Path., Bull. No. 2, 1892, pp. 181, 182.

Shelling.—Conn. (State) Agr. Exp. Sta., Rept. 1896, pp. 278–281. Mich. Agr. Exp. Sta., Bull. No. 121, 1895, p. 51. N. Y. (Cornell Univ.) Agr. Exp. Sta., Bull. No. 76, 1894, pp. 413–440, 452–454.

LETTUCE (*Lactuca sativa*, L.).

Top-burn.—Mass. Hatch Exp. Sta., Bull. No. 69, p. 38; also Rept. 1897, pp. 82–84.

LILY (*Lilium*, spp.).

Bermuda Lily Disease.—U. S. Dept. Agr., Div. Veg. Phys. and Path., Bull. No. 14, 1897.

MELON (*Cucumis Melo*, L.).

Top-burn.—Ga. Agr. Exp. Sta., Bull. No. 57, 1902, p. 190.

ORANGES, LEMONS, ETC. (*Citrus*, spp.).

Blight.—U. S. Dept. Agr., Div. Veg. Phys. and Path., Bull. No. 8, 1896, pp. 9–14. U. S. Dept. Agr., Journ. Mycol., Vol. VII., 1894, pp. 32–34.

Die-back or Exanthema.—Cal. Agr. Exp. Sta., Bull. No. 138, 1902, pp. 40, 41. Fla. Agr. Exp. Sta., Bull. No. 53, 1900, pp. 157–161. U. S. Dept. Agr., Div. Veg. Phys. and Path., Bull. No. 8, 1896, pp. 14–20. U. S. Dept. Agr., Journ. Mycol., Vol. VII., 1894, pp. 29, 30.

Foot-rot or Mal di Gomma. — Fla. Agr. Exp. Sta., Bull. No. 53, 1900, pp. 151–155. U. S. Dept. Agr., Div. Veg. Phys. and Path., Bull. No. 8, 1896, pp. 28–33. U. S. Dept. Agr., Journ. Mycol., Vol. VII., 1894, pp. 30–32.

Melanose. — Fla. Agr. Exp. Sta., Bull. No. 53, 1900, pp. 168, 169. U. S. Dept. Agr., Div. Veg. Phys. and Path., Bull. No. 8, 1896, pp. 33–38.

Peach (*Prunus Persica*, Benth. and Hook.).

Bordeaux Injury. — Conn. (State) Agr. Exp. Sta., 24th Ann. Rept. 1900, pp. 219–254. N. Y. (Cornell Univ.) Agr. Exp. Sta., Bull. No. 164, 1899, pp. 385–388. See *Plum.* Tenn. Agr. Exp. Sta., Bull., Vol. XV., No. 2, 1902.

Dropsical Swellings of Twigs and Branches. — Ohio Agr. Exp. Sta., Bull. No. 92, 1898, pp. 206–208.

Fruit-crack or Sun-scald. — Col. Agr. Exp. Sta., Bull. No. 41, 1898, pp. 15–18.

Gum Disease. — Mich. Agr. Exp. Sta., Rept. 1896, pp. 123, 124; also Rept. 1897, p. 96. Mich. Agr. Exp. Sta., Bull. No. 156, 1898, p. 304.

Little Peach. — Mich. Agr. Exp. Sta., Rept. 1896. pp. 121, 122; also Bull. No. 156, 1898, pp. 303, 304.

Mechanical Injuries, etc. — Ohio Agr. Exp. Sta., Bull. No. 92, 1898, pp. 189, 190.

Rosette. — Ga. Agr. Exp. Sta., Bull. No. 42, 1898, p. 221. Maryland Agr. Exp. Sta., Bull. No. 42, 1896, pp. 160–162. Oklahoma Agr. Exp. Sta., Bull. No. 20, 1896, p. 21. U. S. Dept. Agr., Div. Veg. Path., Bull. No. 1, 1891. U. S. Dept. Agr., Farmers' Bull. No. 17, pp. 13–17. U. S. Dept. Agr., Journ. Mycol., Vol. VI., pp. 143–148. U. S. Dept. Agr., Journ. Mycol., Vol. VII., 1894, pp. 226–232.

Twig Diseases, — Gum-flow. — Ohio Agr. Exp. Sta., Bull. No. 92, 1898, pp. 199–206.

Twig Spots. — Ohio Agr. Exp. Sta., Bull. No. 92, 1898, p. 208.

Yellows. — Conn. (State) Agr. Exp. Sta., Bull. No. 111, 1892, pp. 7, 8; also Bull. No. 115. Delaware Agr. Exp. Sta., Rept. 1893, pp. 152, 153; also Rept. 1897, pp. 168–173. Ga. Agr. Exp. Sta., Bull. No. 42, 1898, p. 220. Maryland Agr. Exp. Sta., Bull. No. 42, 1896, pp. 157–160. Mass. Bull. Bussey Inst. (Harvard Univ.), Vol. III., Pt. 1, 1901. Mass. Hatch Exp. Sta., Bull. No. 8, 1890, pp. 6–12. Mich. Agr. Exp. Sta., Bull. No. 103, 1894, pp. 46–53. N. J. Agr. Exp. Sta., Rept. 1898, pp. 357–359; also Rept. 1899, pp. 417, 418. N. Y. (Cornell Univ.) Agr. Exp. Sta., Bull. No. 25, 1890, pp. 178–180; also Bull. No. 75, 1894, pp. 392–408. No. Car. Agr. Exp. Sta., Bull. No. 92, 1893, pp. 101, 102, 112; also Bull. No. 120, 1895, pp. 300, 301. Ohio Agr. Exp. Sta., Bull. No. 104, 1899, pp. 212–216; also Bull. No. 92, 1898, pp. 190–199. Pa. Agr. Exp. Sta., Bull. No. 37, 1896, pp. 21–23. U. S. Dept. Agr., Div. Veg. Path., Bull. No. 4, 1893. U. S. Dept. Agr., Div. Veg. Path., Bull. No. 1, 1891. U. S. Dept. Agr., Farmers' Bull. No. 17, 1894. U. S. Dept. Agr., Sec. Veg. Path., Bull. No. 9, 1888. W. Va. Agr. Exp. Sta., Bull. No. 66, 1900, pp. 214, 215.

Pear (*Pirus communis*, L.).

Frost Injuries. — Col. Agr. Exp. Sta., Bull. No. 41, 1898, pp. 15–18 (tree trunk). See *Plum* and *Peach.* Conn. (State) Agr. Exp. Sta., 19th Rept. 1895, p. 190 (on fruit). Vt. Agr. Exp. Sta., Bull. No. 49, 1895, p. 100 (on fruit). See *Apple.*

Plum (*Prunus*, spp.).

Frost-cracks and Sun-scald. — Cal. Agr. Exp. Sta., Bull. No. 41, 1898, pp. 15–18. Del. Agr. Exp. Sta., Bull. No. 57, 1902, pp. 13–15.

Gummosis. — Ohio Agr. Exp. Sta., Bull. No. 79, 1897, pp. 121, 122. Oregon Agr. Exp. Sta., Bull. No. 45, 1897, pp. 68–72.

Yellows. — Consult *Peach* literature. Mass. Hatch Exp. Sta., Rept. 1903, p. 35.

Potato (*Solanum tuberosum*, L.).

Arsenical Poisoning. — Vt. Agr. Exp. Sta., Bull. No. 49, 1895, pp. 97, 98; also Bull. No. 72, 1899, pp. 9, 10.

Internal Brown Rot. — Minn. Agr. Exp. Sta., Bull. No. 39, 1894, pp. 212, 213. Minn. Agr. Exp. Sta., Bull. No. 45, 1895, p. 310. N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 101, pp. 78–83; also Rept. 1896, pp. 504–509.

Pimply Potatoes. — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 101, 1896, pp. 84, 85; also Rept. 1896, p. 511.

Stem-blight. — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 101, 1896, pp. 83, 84; also Bull. No. 138, 1897, pp. 632–634.

Sun-scald. — Vt. Agr. Exp. Sta., Bull. No. 72, 1899, pp. 12, 13.

Tip-burn. — U. S. Dept. Agr., Farmers' Bull. No. 91, p. 10. Vt. Agr. Exp. Sta., Bull. No. 49, 1895, pp. 98, 99; also Bull. No. 72, 1899, pp. 10–12.

QUINCE (*Pirus Cydonia*).

Frost-blisters (Leaves). — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 220, 1902, pp. 224, 225.

RASPBERRY (*Rubus*, spp.).

Yellows. — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 226, 1902, pp. 362–364.

RICE (*Oryza sativa*, L.).

Blast. — S. C. Agr. Exp. Sta., Bull. No. 41, 1899, pp. 3–7.

ROSE (*Rosa*, spp.).

Bronzing of Leaves. — Mass. Hatch Exp. Sta., Rept. 1899, pp. 156–159. N. J. Agr. Exp. Sta., Rept. 1891, pp. 303, 304.

TOBACCO (*Nicotiana Tabacum*, L.).

Mosaic Disease, "Calico" or Mottled Top. — Conn. (State) Agr. Exp. Sta., Rept. 1898, pp. 242–260; also Rept. 1899, pp. 252–261. U. S. Dept. Agr., Beau. Plant Indus., Bull. No. 18, 1902.

Spotting. — Conn. (State) Agr. Exp. Sta., Rept. 1898, pp. 254–260; also, Rept. 1899, pp. 252–261.

TOMATO (*Lycopersicum esculentum*, Mill.).

Dropping of Buds. — Fla. Agr. Exp. Sta., Bull. No. 21, 1893, pp. 37, 38; also Bull. No. 47, 1898, pp. 148–151.

Hollow Stem. — Fla. Agr. Exp. Sta., Bull. No. 47, 1898, pp. 151–153.

Œdema. — Fla. Agr. Exp. Sta., Bull. No. 47, 1898, pp. 146–148. N. Y. (Cornell Univ.) Agr. Exp. Sta., Bull. No. 53, 1893. Vt. Agr. Exp. Sta., 6th Rept. 1892, p. 88.

MISCELLANEOUS.

Arsenical Injuries. — Cal. Agr. Exp. Sta., Bull. No. 151, 1903.

Lichens, Mosses, etc. — Fla. Agr. Exp. Sta., Bull. No. 53, 1900, pp. 169–173.

Shade Trees. — Mechanical injuries, etc.: Conn. (State) Agr. Exp. Sta., Bull. No. 131, 1900; also 24th Rept. 1900, pp. 330–351. N. Y. (Cornell Univ.) Agr. Exp. Sta., Bull. No. 205, 1902.

Leaf-scorch or wilt: Vt. Agr. Exp. Sta., 13th Rept. 1899–1900, pp. 281, 282. Mass. Hatch Exp. Sta., Rept. 1897, pp. 81, 82. N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 162, 1899, pp. 177, 178.

Illuminating gas, steam, etc.: Mass. Hatch Exp. Sta., Rept. 1899, pp. 163–167.

Loss of foliage: Mass. Hatch Exp. Sta., Rept. 1899, pp. 153, 154.

Current electricity, lightning: Mass. Hatch Exp. Sta., Bull. No. 91, 1903.

Sunstroke: Kentucky Agr. Exp. Sta., Bull. No. 47, 1893, pp. 6–8.

Smoke and Atmospheric Gases. — Pa. State Coll. Publication (Prof. Buckhout), 1900 (effects on trees). Utah Agr. Exp. Sta., Bull. No. 88, 1903 (effects on crops).

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

At the beginning of the year a change was made in the times of observation, from 7 A.M., 2 P.M. and 9 P.M. to 8 A.M. and 8 P.M. This was done in order to make them synchronous with those of the United States Weather Bureau, this station being one of the voluntary stations of that service. This change has made no appreciable difference in the daily means compared with those of previous years, excepting those of relative humidity, where the omission of the observation near midday seems to have resulted in a higher mean. The effect, however, can be more definitely determined after the change has been in operation for a number of years.

As in previous years, much of the work of this division has been that of observation and transcription of the records in permanent form. The usual bulletins have been regularly issued at the beginning of each month, containing the more important daily records, together with the monthly means, and remarks on any unusual features that occurred. An annual summary will be made a part of the December bulletin.

The local forecasts have been regularly received from the Boston office of the United States Weather Bureau, and the signals displayed from the flag-staff on the tower. This station is furnishing the weekly reports for the "snow and ice" bulletin, as has been done the last few years.

In addition to furnishing the section director of the Weather Bureau with the voluntary observers' reports, as well as our printed bulletin, at his request early in the year all the records at this station were examined and the data tabulated to be used in a climatological directory of the principal stations of the United States. A phenological record was also kept during the growing season, and two copies furnished the section director as requested.

As a part of the college exhibit for the Louisiana Purchase Exposition at St. Louis, this division prepared a number of charts in water colors, showing many of the meteorological features of the station. Photographs of most of our self-recording instruments were also sent.

Two new clocks for the Draper instruments were purchased during the year, to replace others that had become unreliable.

Mr. F. F. Henshaw retired as observer upon his graduation in June, and was succeeded by the assistant observer, Mr. G. W. Patch.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.

Chemical Assistants: E. B. HOLLAND, P. H. SMITH and E. S. FULTON.
Inspector of Feeds and Babcock Machines: ALBERT PARSONS.
Dairy Tester: SUMNER R. PARKER.
In Charge of Feeding Experiments: JOSEPH G. COOK.
Stenographer: MABEL C. SMITH.

PART I. — THE WORK OF THE YEAR.

1. Correspondence.
2. General laboratory work.
3. Character of laboratory work.
    - (*a*) Water.
    - (*b*) Dairy products and cattle feeds.
    - (*c*) Chemical investigations.
4. Inspection of concentrates.
5. Execution of the dairy law.
6. Test of pure-bred cows.
7. Work completed and in progress.
8. Changes in staff.

PART II. — EXPERIMENTS IN ANIMAL NUTRITION.

1. Digestion experiments with sheep.
2. The digestibility of galactan.
3. The feeding value of apple pomace.
4. Blomo feed for horses.

PART I. — THE WORK OF THE YEAR.

J. B. LINDSEY.

1. CORRESPONDENCE.

The general character of the correspondence has been much the same as in former years, and the amount has been approximately 4,000 letters and postals, in addition to some 1,000 circulars relative to adulterated mixed feeds.

2. GENERAL LABORATORY WORK.

The work in the laboratory has been of the same character as formerly. The number of determinations of butter fat in milk has greatly increased.

There have been sent in for examination 104 samples of water, 773 of milk, 1,779 of cream, 2 of butter and 153 of feed stuffs. In connection with experiments by this and other divisions of the station, there have been analyzed, in whole or in part, 234 samples of milk and cream and 530 of fodders and feed stuffs. There have also been collected and tested under the provision of the feed law 686 samples of concentrated feed stuffs. This makes a total of 4,261 substances analyzed during the year, as against 3,897 last year and 3,240 in the previous year. Work on the availability of organic nitrogen, not included in the above, has been done for the Association of Official Agricultural Chemists. In addition, 20 candidates have been examined and given certificates to operate Babcock machines, and 2,026 pieces of glassware have been tested for accuracy, of which 200 pieces, or 9.87 per cent., were condemned.

3. CHARACTER OF LABORATORY WORK.

(a) *Water.*

In accordance with instructions from the experiment station committee, this department continues to charge the sum of $3 for a sanitary analysis of water. The number of samples examined has been 104, which is considerably less than when the work was done free of cost. It is believed that this charge has held in check those who have heretofore abused the privilege by sending in a large number of samples, in some cases out of mere curiosity.

Instructions for securing an analysis of water: —

Those wishing to secure a sanitary analysis of water must first make application, whereupon a glass bottle securely encased, accompanied by full instructions for collecting and shipping the sample, will be forwarded by express. The return express must in all cases be prepaid. Because of the smallness of the sum involved, no account will be opened. Remittance by check, P. O. money order, or money at the owner's risk, must be strictly in advance.

Address Dr. J. B. Lindsey,
Hatch Experiment Station, Amherst, Mass.

(*b*) *Dairy Products and Cattle Feeds.*

The station received about the usual number of samples of milk and cream. Many samples are sent by farmers to ascertain the quality of milk produced by their herd or by individual cows, and this should meet with every encouragement. Printed circulars are sent in answer to inquiries, giving concise information concerning the quality of milk produced by different breeds, as well as full instructions relative to the best methods of determining the productive capacity of the dairy herd. The station also tests a large number of samples of milk and cream for creameries at a charge sufficient to cover the cost.

About the usual number of feed stuffs were received during the year. These come from practical feeders, who either suspect adulteration, or desire to know the value of a feed new to their locality. The results of the examination are returned promptly, together with such information as is suited to the particular case. A considerable number of samples are also received from feed dealers, who wish to make sure as to the intrinsic value of the materials they are offering. It is believed that this desire for information should be encouraged as much as the limited resources of the department permit.

(c) *Chemical Investigations.*

In so far as time and opportunity permit, the department aims to make a study of chemical methods that will facilitate the accurate and rapid determinations of the different substances connected with animal or plant life. In this study of methods the department co-operates yearly with the Association of Official Agricultural Chemists.

4. Inspection of Concentrates.

The passage of the feed law by the Legislature of 1903 makes it possible to give the attention to this line of work which its importance demands. A regular inspector is now employed, who travels through the State from six to eight months in the year, so that the station is kept well informed regarding the variety and character of the feeds offered for sale. The results of the several inspections were published in Bulletins Nos. 93 and 98, issued in January and August. These bulletins contained 52 and 36 pages respectively. It may be said that the major portion of the feeds now offered are properly branded and free from adulteration; still, some manufacturers and local dealers continue to be careless about attaching the proper form of guarantee, and, while the station has not prosecuted any cases as yet, there will be no hesitation in doing so if occasion makes it necessary.

A tendency is noted on the part of both manufacturers and dealers to mix more or less oat offal or other filler with standard by-products, thus reducing the cost of the article sufficiently to enable them to slightly undersell their competitors. The station is taking a firm stand against such deceptions.

During the present autumn a considerable quantity of wheat mixed feed, bran and middlings, was found considerably adulterated with ground corn cobs and wheat screenings. The prompt attention of the jobbers was called to the matter, and they took steps immediately to attach the proper guarantee. A special circular relative to this fraud was sent to all the principal grain dealers in the State, as well as to the agricultural press.

It is not necessary to make a chemical analysis of as many samples as formerly. More attention is being given to the work of careful inspection and to the collecting of those samples which are suspected of being below standard or adulterated. The correspondence in connection with this police work, as it may be termed, requires a great deal of time and patience. It is believed that all farmers and dairymen can now keep themselves well posted upon the character and value of the large variety of feeds offered, if they are disposed to do so. Interested parties are referred to the various feed bulletins for details. Bulletin No. 101, comprising the results of the autumn inspection, is now in press, and will be issued during the present month (December).

5. Execution of the Dairy Law.

The enforcement of this law has been given the same careful attention as in previous years.

Inspection of Glassware. — All glassware found to be correctly graduated has been marked "Mass Ex St." There were 2,026 pieces examined, of which 200, or 9.87 per cent., were condemned. Inaccurate graduation of bottles has been rather more noticeable of late than at any time since the early days of the inspection. This is to be regretted, and it is hoped the manufacturers will take immediate action to prevent a possible recurrence. Bulb cream bottles (Bartlett) have been previously passed on accuracy of total graduation, as the usual charge of 5 cents apiece would not permit of additional testing. The continued use of these bottles by some of the prominent milk depots has rendered it necessary to test the three distinct portions of the scale, at a corresponding increase in cost.

Examination of Candidates. — A few more candidates than usual were examined, and 20 certificates of competency issued. A considerable number showed very poor manipulation, and lacked a thorough understanding of the method. In case of failure, applicants are obliged to wait a month before a second examination will be given.

Inspection of Babcock Machines. — The inspection of machines the present year has been in charge of Mr. Albert Parsons, who makes the following report: —

The annual inspection of Babcock machines was made in November of 1904. Fifty-six establishments were either visited or heard from, 36 being creameries and 20 milk depots. Twenty-one, or one-third the number, are co-operative, while the other 35 are proprietary, or managed by stock companies. Thirty-six machines were inspected. The number is 4 less than last year, due to the fact that 2 creameries and 1 milk depot have been discontinued, and 1 milk depot does not use its tester. Some machines overheated the tests, and a few required additional steam to warm them. One needed slight repairs of the steam gauge, but the others were in satisfactory condition, and in general showed an improvement over last year. Steam was the motive power in every case except one, where electricity was used. All but 5 of the machines have frames of cast iron, which is taking the place of galvanized iron and copper. Of the cast-iron machines, 19 are "Facile," 10 "Agos," and 2 "Wizard." The last named has only recently been placed upon the market. As a rule, the glassware was found in good condition, although in a few cases it was very dirty. In addition to the regular inspection, two city milk inspectors were visited. Each had a "Wizard" cast-iron machine, one being run by electricity and the other by a water motor. The electrical machine did not have sufficient power for the necessary speed. The other was in good condition, and a certificate was given.

6. TESTS OF PURE-BRED COWS.

This work has increased to such an extent as to render necessary the employment of a regular tester, Mr. Sumner R. Parker of the class of 1904 of this college, who gives it his whole time. The testing is conducted under the supervision of the American Guernsey and Jersey cattle clubs and the Holstein-Friesian Association. The work consists largely in determining the yearly milk and butter fat yields of pure-bred cows of the several breeds. The inspector visits the farms monthly, weighs the milk for one or two days, determines the butter fat by the Babcock method, and reports his findings to the secretary of the respective clubs, together with such other data, relative to feed, scattered milkings, etc., as are required. These tests are known as "yearly milk and butter fat tests," or "authenticated butter fat estimate and milk record." There are at present

51 Guernsey and Jersey cows under test, belonging to F. Lothrop Ames of North Easton, N. I. Bowditch of Framingham, W. L. Cutting of Pittsfield, R. F. and A. H. Parker of Westborough, A. H. Sagendorph of Spencer, C. I. Hood of Lowell, A. F. Pierce of Winchester, N. H., and R. A. Sibley of Spencer.

In addition, seven-day butter tests are occasionally called for by the Jersey Cattle Club, in which case it becomes necessary to weigh, sample and test not only the milk but the skim milk, buttermilk and butter; and the total fat in the three latter, together with that in the test samples, should balance the fat in the original milk, with the exception of small mechanical losses. The butter is analyzed at the station laboratory. Seven-day tests are also made for the Holstein-Friesian Association, which simply calls for the amount of milk and butter fat produced by the animal during that period.

7. Work completed and in Progress.

In addition to Bulletins Nos. 93 and 98, devoted to the inspection of feeding stuffs, this department has published during the year Bulletin No. 94, on distillery and brewery by-products, and Bulletin No. 99, on dried molasses beet pulp, and nutrition of horses. An experiment has been completed on the use of dried blood as a source of protein for milk production, showing that digestible protein in this material is equal in feeding value to a similar amount in cotton-seed meal. An experiment has also been completed with Pratts food as an aid to milk production. The results make clear that the claims put forward by the manufacturers relative to the wonderful influence of this food in increasing the quantity and quality of milk are entirely without foundation. Bibby's dairy cake has also been compared with gluten feed for the production of milk, and, while the results are not yet entirely tabulated, it is quite evident that the Bibby cake possesses no particular merits over other feed stuffs of a similar composition, and that the price asked is out of proportion to its actual feeding value. A number of experiments have been in progress with green forage crops, but, as the results at present are only of a tentative character, they will not be published until it is possible to deduce more definite conclusions.

Some 34 tons of corn and soy beans were grown together the past season on a little less than 3 acres of land, and the fodder ensiled. The silo has been recently opened, the silage appears in good condition and is readily eaten. It was not found possible to cut this mixture satisfactorily with a corn harvester, and the writer is forced to the conclusion that, until this can be accomplished, it will be doubtful economy to attempt to grow it to any extent for silage purposes. It is believed that the value of the extra protein obtained is more than offset by the increased cost of harvesting the crop.

Experiments are in progress relative to the value of molasses and molasses feeds as food for dairy stock and horses, and will occupy a considerable portion of the winter months. Attention is called to the several completed experiments published in Part II. of this report.

8. Changes in Staff.

Mr. W. E. Tottingham, employed in this department as assistant chemist for a year, resigned September 1 to continue his studies in the chemical department of the college. His work was very satisfactory. Mr. E. S. Fulton of the class of 1904 of the college succeeded Mr. Tottingham. Mr. S. R. Parker, another graduate of the class of 1904, began his duties August 1 as dairy tester. He is kept constantly employed in this line of work.

PART II. — EXPERIMENTS IN ANIMAL NUTRITION.

1. DIGESTION EXPERIMENTS WITH SHEEP.

J. B. LINDSEY.[1]

This station has given considerable time and study to the digestibility of coarse and concentrated cattle feeds. The first experiments were made in the autumn and winter of 1892–93, and the results published, together with a description of the method employed, in the eleventh report of the Massachusetts State Experiment Station. The results of further experiments were published in the twelfth report. A summary of all experiments made between 1894 and 1902 will be found in the fifteenth report of the Hatch Experiment Station, pp. 82–101. Experiments made during 1902 appeared in the sixteenth report of this station.

The experiments here described were made during the autumn of 1903 and winter and spring of 1904. The full data are here presented, with the exception of the daily production of manure and the daily water consumption, in which cases, to economize space, only averages are presented.

The period extended over fourteen days, the first seven of which were preliminary, collection of fæces being made during the last seven. Ten grams of salt were fed each sheep daily, in addition to the regular ration. Water was before the animals at all times.

Two lots of sheep, grade Southdown wethers, were employed in the several trials, known as the old and the young sheep. The former were five to six years of age, and had been used by the station for a number of years; the latter were dropped in 1902, and were employed for the first time during the autumn and winter of 1903–04.

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[1] With E. B. Holland, P. H. Smith, W. E. Tottingham and J. G. Cook.

The digestion coefficients for the digestion hay, used in calculating the results of the several experiments with the old sheep, were those obtained with Sheep II. and III., Sheep I. having been disposed of before the digestibility of the hay was determined.

The individual coefficients were used for the young sheep, being obtained from the average of the two trials in the case of Sheep I. and II., and that of the single trial for Sheep III.

Hay Coefficients used (Per Cent.).

	Old Sheep.	Young Sheep.		
		I.	II.	III.
Dry matter,	58.50	49.89	54.34	51.53
Ash,	22.00	13.86	22.60	16.55
Protein,	42.50	37.37	37.72	36.66
Fiber,	61.00	49.98	55.85	53.13
Extract matter,	64.00	56.29	59.77	57.02
Fat,	46.50	38.54	44.19	36.97

In calculating the digestion coefficients when English hay was used, excepting in periods IV., V. and XII., the average analysis of the two samples of hay was employed.

Composition of Feed Stuffs (Per Cent.).

[Dry matter.]

Feeds.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Soy bean fodder,	11.82	20.03	22.12	42.55	3.48
Waste soy bean fodder, Sheep II.,	8.64	4.85	55.47	30.33	.71
Eureka silage corn fodder,	6.19	9.34	27.41	55.52	1.54
Apple pomace,	3.05	5.13	16.10	69.32	6.40
Cotton-seed meal fed with pomace,	6.95	52.16	5.88	25.91	9.10
English hay fed to new sheep,	6.53	6.23	33.00	52.27	1.97
Waste English hay,[1] Sheep III., fine hay and seeds.	29.19	6.76	21.67	40.25	2.13
English hay fed to old sheep,	6.35	6.24	31.95	53.15	2.31
Bibby's dairy cake,	9.14	23.52	9.28	48.06	10.00
Bibby's dairy cake (1903),	8.38	21.39	9.19	50.42	10.62
Alma dried molasses-beet-pulp,	5.64	9.87	17.17	66.74	.58

[1] Contained 21.39 per cent. of salt.

Composition of Feed Stuffs (Per Cent.) — Concluded.

[Dry matter.]

FEEDS.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Armour's blood meal,	3.37	95.24	.88	–	.51
Corn meal fed with blood meal,	1.41	9.87	2.09	82.25	4.38
Soy bean meal, coarse ground,	5.73	40.69	4.71	27.77	21.10
Hominy feed,	3.15	11.66	5.46	70.11	9.62
Hominy meal (1903),	3.38	12.23	4.97	69.43	9.99
Eureka silage corn fodder (dry),	7.85	9.82	32.70	47.90	1.73
Waste corn stover, Sheep II.,	9.85	9.16	34.13	45.07	1.79
English hay,[1]	6.46	6.74	32.28	52.16	2.36
Waste English hay, Sheep I.,	6.94	6.17	32.72	52.05	2.12
Waste English hay,[2] Sheep II.,	14.99	6.95	27.41	48.22	2.43

[1] Used in Period XII.

[2] Contained 7.38 per cent. of salt.

Composition of Fæces (Per Cent.).

[Dry matter.]

Old Sheep I.

Period.	FEEDS.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
I.,	Soy bean fodder,	18.55	8.62	33.83	35.99	3.01
II.,	Eureka silage corn fodder,	9.87	8.77	33.67	46.28	1.41
III.,	Apple pomace,	9.93	18.53	24.38	40.21	6.95
XXVI. (1903),	Bibby's dairy cake,	12.88	14.93	27.19	41.62	3.38
XXVIII. (1903),	Hominy meal,	11.31	13.41	28.49	43.33	3.46

Old Sheep II.

Period.	FEEDS.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
I.,	Soy bean fodder,	19.95	9.44	33.48	34.05	3.08
II.,	Eureka silage corn fodder,	11.47	9.85	31.70	45.30	1.68
III.,	Apple pomace,	9.93	17.97	23.24	41.07	7.79
V.,	English hay,	11.78	8.42	30.93	46.03	2.84
VII.,	Alma dried molasses-beet-pulp,	12.37	10.80	29.21	44.15	3.47
IX.,	Soy bean meal,	12.87	9.82	29.50	44.64	3.17
XI.,	Eureka silage corn fodder (dry),	12.73	11.58	26.04	47.87	1.78
XXVI. (1903),	Bibby's dairy cake,	13.89	14.86	26.54	41.23	3.48
XXVIII. (1903),	Hominy meal,	12.91	14.22	25.99	43.21	3.67

Composition of Fæces (Per Cent.) — Concluded.

[Dry matter.]

Old Sheep III.

Period.	FEEDS.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
I.,	Soy bean fodder,	19.96	9.34	32.18	35.34	3.18
II.,	Eureka silage corn fodder,	10.92	9.14	32.41	45.89	1.64
III.,	Apple pomace,	11.44	20.82	19.82	40.40	7.52
V.,	English hay,	12.15	9.01	29.49	46.18	3.17
VII.,	Alma dried molasses-beet-pulp,	12.51	11.21	27.82	45.04	3.42
IX.,	Soy bean meal,	12.02	10.67	26.56	46.96	3.79
XI.,	Eureka silage corn fodder (dry),	12.79	11.84	25.27	48.29	1.81
XXVI. (1903),	Bibby's dairy cake,	13.93	15.59	24.63	41.87	3.98
XXVIII. (1903),	Hominy meal,	13.06	14.88	24.06	43.41	4.59
	Young Sheep I.					
IV.,	English hay,	11.16	7.86	32.51	45.75	2.72
VI.,	Bibby's dairy cake,	12.62	11.19	30.20	43.41	2.58
VIII.,	Armour's blood meal,	10.64	13.03	31.49	42.29	2.55
X.,	Marshall's hominy feed,	10.98	10.81	29.89	45.47	2.85
XII.,	English hay,	11.12	8.38	32.64	45.34	2.52
	Young Sheep II.					
IV.,	English hay,	10.70	8.40	31.51	46.74	2.65
VI.,	Bibby's dairy cake,	12.03	12.50	30.29	42.61	2.57
VIII.,	Armour's blood meal,	10.47	15.57	29.30	42.23	2.43
X.,	Marshall's hominy feed,	10.72	11.30	30.08	45.36	2.54
XII.,	English hay,	11.21	9.26	31.72	45.24	2.57
	Young Sheep III.					
IV.,	English hay,	10.92	7.97	32.20	46.40	2.51
VI.,	Bibby's dairy cake,	12.90	11.08	31.30	42.36	2.36
X.,	Marshall's hominy feed,	10.62	9.97	30.60	46.14	2.67

Dry Matter Determinations made at Time of Weighing out the Different Foods, and Dry Matter in Manure excreted, determined from Air-dry Fæces (Per Cent.).

Old Sheep I.

PERIODS.	English Hay.	Soy Bean Fodder.	Eureka Silage Corn Fodder.	Apple Pomace.	Cotton-seed Meal.	Alma Dried Molasses-beet-pulp.	Soy Bean Meal.	Eureka Silage Corn Fodder (Dry).	Bibby's Dairy Cake.	Hominy Meal.	Waste.	Manure.
I., . .	87.27	23.94	–	–	–	–	–	–	–	–	–	91.02
II., . .	–	–	17.42	–	–	–	–	–	–	–	–	89.82
III., . .	87.05	–	–	19.83	89.34	–	–	–	–	–	–	92.28
XXVI. (1903),	88.82	–	–	–	–	–	–	–	89.80	–	–	92.43
XXVIII. (1903),	88.25	–	–	–	–	–	–	–	–	88.48	–	92.98

Old Sheep II.

I., . .	87.27	23.94	–	–	–	–	–	–	–	–	96.37	90.82
II., . .	–	–	17.42	–	–	–	–	–	–	–	–	89.93
III., . .	87.05	–	–	19.83	89.34	–	–	–	–	–	–	92.00
V., . .	88.10	–	–	–	–	–	–	–	–	–	–	92.50
VII., . .	87.82	–	–	–	–	92.62	–	–	–	–	–	93.55
IX., . .	88.37	–	–	–	–	–	86.96	–	–	–	–	94.42
XI., . .	–	–	–	–	–	–	–	40.08	–	–	51.19	93.84
XXVI. (1903),	88.82	–	–	–	–	–	–	–	89.80	–	–	92.66
XXVIII. (1903),	88.25	–	–	–	–	–	–	–	–	88.48	–	92.54

Old Sheep III.

I., . .	87.27	23.94	–	–	–	–	–	–	–	–	–	90.77
II., . .	–	–	17.42	–	–	–	–	–	–	–	–	89.81
III., . .	87.05	–	–	19.83	89.34	–	–	–	–	–	–	91.88
V., . .	88.10	–	–	–	–	–	–	–	–	–	–	92.56
VII., . .	87.82	–	–	–	–	92.62	–	–	–	–	–	93.60
IX., . .	88.37	–	–	–	–	–	86.96	–	–	–	–	94.61
XI., . .	–	–	–	–	–	–	–	40.08	–	–	–	93.84
XXVI. (1903),	88.82	–	–	–	–	–	–	–	89.80	–	–	92.84
XXVIII. (1903),	88.25	–	–	–	–	–	–	–	–	88.48	–	92.91

Dry Matter Determinations, etc. — Concluded.

Young Sheep I.

PERIODS.	English Hay.	Bibby's Dairy Cake.	Armour's Blood Meal.	Corn Meal.	Marshall's Hominy Feed.	Waste.	Manure.
IV., . .	87.90	–	–	–	–	86.65	93.36
VI., . .	88.05	89.45	–	–	–	–	93.78
VIII., . .	87.85	–	88.70	86.13	–	–	93.45
X., . .	89.30	–	–	–	88.53	–	94.06
XII., . .	89.77	–	–	–	–	87.00	93.22

Young Sheep II.

PERIODS.	English Hay.	Bibby's Dairy Cake.	Armour's Blood Meal.	Corn Meal.	Marshall's Hominy Feed.	Waste.	Manure.
IV., . .	87.90	–	–	–	–	–	93.27
VI., . .	88.05	89.45	–	–	–	–	93.55
VIII., . .	87.85	–	88.70	86.13	–	–	93.33
X., . .	89.30	–	–	–	88.53	–	93.78
XII., . .	89.77	–	–	–	–	87.80	92.84

Young Sheep III.

PERIODS.	English Hay.	Bibby's Dairy Cake.	Armour's Blood Meal.	Corn Meal.	Marshall's Hominy Feed.	Waste.	Manure.
IV., . .	87.90	–	–	–	–	88.50	93.25
VI., . .	88.05	89.45	–	–	–	–	94.16
X., . .	89.30	–	–	–	88.53	87.80	94.08

Average Daily Amount of Manure excreted and Water drank (Grams).

Period.	CHARACTER OF RATION.	OLD SHEEP I.			OLD SHEEP II.			OLD SHEEP III.		
		Manure excreted daily.	Sample Air Dry.	Water drank daily.	Manure excreted daily.	Sample Air Dry.	Water drank daily.	Manure excreted daily.	Sample Air Dry.	Water drank daily.
I.,	Soy bean fodder,	699	35.09	1,409	684	34.26	1,492	679	34.67	1,296
II.,	Eureka silage corn fodder,	630	23.53	–	506	20.70	–	481	21.77	–
III.,	Apple pomace,	669	27.29	536	581	24.68	414	818	25.95	–
V.,	English hay,	–	–	–	806	36.94	1,067	717	33.92	1,391
VII.,	Alma dried molasses-beet-pulp,	–	–	–	613	27.13	1,379	623	28.69	1,386
IX.,	Soy bean meal,	–	–	–	736	27.48	1,264	860	30.62	1,638
XI.,	Eureka silage corn fodder (dry),	–	–	–	400	16.61	516	506	18.55	1,006
XXVI. (1903),	Bibby's dairy cake,	923	31.86	2,370	703	27.13	1,688	784	30.68	1,992
XXVIII. (1903),	Hominy meal,	700	28.73	2,500	825	26.25	2,017	637	23.14	2,198

Average Daily Amount of Manure excreted, etc. — Concluded.

Period.	CHARACTER OF RATION.	YOUNG SHEEP I.			YOUNG SHEEP II.			YOUNG SHEEP III.		
		Manure excreted daily.	Sample Air Dry.	Water drank daily.	Manure excreted daily.	Sample Air Dry.	Water drank daily.	Manure excreted daily.	Sample Air Dry.	Water drank daily.
IV.,	English hay,	979	39.76	1,309	831	37.47	2,477	875	36.80	1,827
VI.,	Bibby's dairy cake,	956	32.47	1,368	881	32.52	2,156	915	32.99	2,104
VIII.,	Armour's blood meal,	628	27.88	1,369	628	27.72	2,266	–	–	–
X.,	Marshall's hominy feed,	837	29.49	1,339	912	29.16	1,894	844	30.87	2,076
XII.,	English hay,	994	35.08	1,354	799	33.20	2,467	–	–	–

Weights of Animals at Beginning and End of Period (Pounds).

Period.	CHARACTER OF RATION.	OLD SHEEP I.		OLD SHEEP II.		OLD SHEEP III.	
		Beginning.	End.	Beginning.	End.	Beginning.	End.
I.,	Soy bean fodder,	167.25	168.00	154.50	155.25	152.75	149.50
II.,	Eureka silage corn fodder,	167.50	164.75	156.00	154.50	149.00	145.75
III.,	Apple pomace,	170.75	171.50	157.50	158.25	152.75	153.50
V.,	English hay,	-	-	164.00	162.00	159.50	160.00
VII.,	Alma dried molasses-beet-pulp,	-	-	162.00	162.75	160.50	160.25
IX.,	Soy bean meal,	-	-	163.00	163.25	161.00	158.25
XI.,	Eureka silage corn fodder (dry),	-	-	159.75	157.00	153.75	153.50
XXVI. (1903),	Bibby's dairy cake,	159.00	154.75	155.00	154.25	149.00	146.75
XXVIII. (1903),	Hominy meal,	156.75	152.00	157.25	156.50	150.25	149.00

Weights of Animals, etc. — Concluded.

Period.	CHARACTER OF RATION.	YOUNG SHEEP I.		YOUNG SHEEP II.		YOUNG SHEEP III.	
		Beginning.	End.	Beginning.	End.	Beginning.	End.
IV.,	English hay,	98.50	95.00	97.00	98.25	97.00	96.00
VI.,	Bibby's dairy cake,	95.25	93.00	93.75	92.25	90.25	90.75
VIII.,	Armour's blood meal,	96.25	97.50	91.25	93.50	-	-
X.,	Marshall's hominy feed,	94.00	94.50	88.00	90.25	89.00	89.25
XII.,	English hay,	98.75	96.50	91.50	94.25	-	-

Period I.

Old Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
400 grams English hay,	349.08	22.48	21.78	113.38	183.97	7.47
2,000 grams soy bean fodder,	478.80	56.59	95.90	105.91	203.73	16.66
Amount consumed,	827.88	79.07	117.68	219.29	387.70	24.13
350.87 grams manure excreted,	319.36	59.24	27.53	108.04	114.94	9.61
Grams digested,	508.52	19.83	90.15	111.25	272.76	14.52
Minus hay digested,	204.21	4.95	9.26	69.16	117.74	3.47
Soy bean fodder digested,	304.31	14.88	80.89	42.09	155.02	11.05
Per cent. digested,	63.56	26.29	84.35	39.74	76.09	66.33

Old Sheep II.

2,000 grams soy bean fodder fed,	478.80	56.59	95.90	105.91	203.73	16.66
Minus 36 grams waste,	34.69	3.00	1.69	19.24	10.52	.25
Soy bean fodder consumed,	444.11	53.59	94.22	86.67	193.21	16.41
400 grams English hay,	349.08	22.48	21.78	113.38	183.97	7.47
Amount consumed,	773.19	76.07	116.00	200.05	377.18	23.88
342.59 grams manure excreted,	311.14	62.07	29.37	104.17	105.94	9.58
Grams digested,	482.05	14.00	86.63	95.88	271.24	14.30
Minus hay digested,	204.21	4.95	9.26	69.16	117.74	3.47
Soy bean digested,	277.84	9.05	77.37	26.72	153.50	10.83
Per cent. digested,	62.51	16.89	82.12	30.83	79.45	66.00

Old Sheep III.

Amount consumed same as for Sheep I.,	827.88	79.07	117.68	219.29	387.70	24.13
346.71 grams manure excreted,	314.71	62.82	29.39	101.27	111.22	10.01
Grams digested,	513.17	16.25	88.29	118.02	276.48	14.12
Minus hay digested,	204.21	4.95	9.26	69.16	117.74	3.47
Soy bean fodder digested,	308.96	11.30	79.03	48.86	158.74	10.65
Per cent. digested,	64.53	19.97	82.41	46.13	77.92	63.93
Average per cent. three sheep digested,	**63.53**	**21.05**	**82.96**	**38.90**	**77.82**	**65.42**

Period II.

Old Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
3,400 grams Eureka silage corn,	592.28	36.66	55.32	162.34	328.83	9.12
235.29 grams manure excreted,	211.34	20.86	18.53	71.16	97.81	2.98
Grams digested,	380.94	15.80	36.79	91.18	231.02	6.14
Per cent. digested,	64.32	43.10	66.50	56.17	70.26	67.32

Old Sheep II.

3,400 grams Eureka silage corn,	592.28	36.66	55.32	162.34	328.83	9.12
207.01 grams manure excreted,	186.16	21.35	18.34	59.01	84.33	3.13
Grams digested,	406.12	15.31	36.98	103.33	244.50	5.99
Per cent. digested,	68.57	41.76	66.85	63.65	74.35	65.68

Old Sheep III.

3,400 grams Eureka silage corn,	592.28	36.66	55.32	162.34	328.83	9.12
217.69 grams manure excreted,	195.51	21.35	17.87	63.36	89.72	3.21
Grams digested,	396.77	15.31	37.45	98.98	239.11	5.91
Per cent. digested,	66.99	41.76	67.70	60.97	72.72	64.80
Average per cent. three sheep digested,	**66.63**	**42.21**	**67.02**	**60.26**	**72.44**	**65.93**

Period III.

Old Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
250 grams English hay,	217.63	14.02	13.58	70.69	114.69	4.66
150 grams cotton-seed meal,	134.01	9.31	69.90	7.88	34.72	12.19
2,000 grams apple pomace,	396.60	12.10	20.35	63.85	274.92	25.38
Amount consumed,	748.24	35.43	103.83	142.42	424.33	42.23
272.89 grams manure excreted,	251.82	25.01	46.66	61.39	101.26	17.50
Grams digested,	496.42	10.42	57.17	81.03	323.07	24.73
Minus hay digested,	127.31	3.08	5.77	43.12	73.40	2.17
	369.11	7.34	51.40	37.91	249.67	22.56
Minus cotton-seed meal digested,	101.85	2.23	61.51	2.52	22.22	11.34
Apple pomace digested,	267.26	5.11	–	35.39	227.45	11.22
Per cent. digested,	67.39	42.23	–	55.43	82.73	44.21

Old Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	748.24	35.43	103.83	142.42	424.33	42.33
246.76 grams manure excreted,	227.02	22.54	40.80	52.76	93.24	17.68
Grams digested,	521.22	12.89	63.03	89.66	331.09	24.55
Minus hay and cotton-seed meal digested,	229.16	5.31	67.28	45.64	95.62	13.51
Apple pomace digested,	292.06	7.58	–	44.02	235.47	11.04
Per cent. digested,	73.64	62.64	–	68.94	85.65	43.50

Old Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	748.24	35.43	103.83	142.42	424.33	42.23
259.46 grams manure excreted,	238.39	27.27	49.63	47.25	96.31	17.93
Grams digested,	509.85	8.16	54.20	95.17	328.02	24.30
Minus hay and cotton-seed meal digested,	229.16	5.31	67.28	45.64	95.62	13.51
Apple pomace digested,	280.69	2.85	–	49.53	232.40	10.79
Per cent. digested,	70.77	23.55	–	77.57	84.53	42.51
Average per cent. three sheep digested,	**70.60**	**42.81**	–	**67.31**	**84.30**	**43.41**

Period IV.

Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
850 grams English hay,	747.15	48.79	46.55	246.56	390.54	14.72
Minus 35.86 grams waste,	31.07	2.03	1.94	10.25	16.24	.61
Amount consumed,	716.08	46.76	44.61	236.31	374.30	14.11
397.61 grams manure excreted,	371.21	41.43	29.18	120.68	169.83	10.10
Grams digested,	344.87	5.33	15.43	115.63	204.47	4.01
Per cent. digested,	48.16	11.40	34.59	48.93	54.63	28.42

Young Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
850 grams English hay,	747.15	48.79	46.55	246.56	390.54	14.72
374.71 grams manure excreted,	349.49	37.40	29.36	110.12	163.35	9.26
Grams digested,	397.66	11.39	17.19	136.44	227.19	5.46
Per cent. digested,	53.22	23.34	36.93	55.34	58.17	37.09

Young Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
850 grams English hay,	747.15	48.79	46.55	246.56	390.54	14.72
Minus 56.29 grams waste,	39.16	3.89	3.37	10.80	20.05	1.06
Amount consumed,	707.99	44.90	43.18	235.76	370.49	13.66
368.01 grams manure excreted,	343.17	37.47	27.35	110.50	159.23	8.61
Grams digested,	364.82	7.43	15.83	125.26	211.26	5.05
Per cent. digested,	51.53	16.55	36.66	53.13	57.02	36.97
Average per cent. three sheep digested,	**50.97**	**17.10**	**36.06**	**52.47**	**56.61**	**34.16**

Period V.

Old Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
900 grams English hay,	792.90	50.35	49.48	253.33	421.43	18.32
369.38 grams manure excreted,	341.68	40.25	28.77	105.68	157.28	9.70
Grams digested,	451.22	10.10	20.71	147.65	264.15	8.62
Per cent. digested,	56.91	20.06	41.86	58.28	62.68	47.05

Old Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
900 grams English hay,	792.90	50.35	49.48	253.33	421.43	18.32
339.15 grams manure excreted,	313.92	38.14	28.28	92.58	144.97	9.95
Grams digested,	478.98	12.21	21.20	160.75	276.46	8.37
Per cent. digested,	60.41	24.25	42.85	63.45	65.60	45.69
Average per cent. two sheep digested,	**58.66**	**22.16**	**42.36**	**60.87**	**64.14**	**46.37**

Period VI.

Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay,	528.30	34.02	32.97	171.59	278.41	11.31
200 grams Bibby's dairy cake,	178.90	16.35	42.08	16.60	85.98	17.89
Amount consumed,	707.20	50.37	75.05	188.19	364.39	29.20
324.71 grams manure excreted,	304.51	38.43	34.07	91.96	132.19	7.86
Grams digested,	402.69	11.94	40.98	96.23	232.20	21.34
Minus hay digested,	263.57	4.72	12.32	85.76	156.72	4.36
Bibby's dairy cake digested,	139.12	7.22	28.66	10.47	75.48	16.98
Per cent. digested,	77.76	44.16	68.11	63.07	87.79	94.91

Young Sheep II.

Amount consumed as above,	707.20	50.37	75.05	188.19	364.39	29.20
325.20 grams manure excreted,	304.22	36.60	38.03	92.15	129.63	7.82
Grams digested,	402.98	13.77	37.02	96.04	234.76	21.38
Minus hay digested,	287.08	7.69	12.44	95.83	166.41	5.00
Bibby's dairy cake digested,	115.90	6.08	24.58	.21	68.35	16.38
Per cent. digested,	64.78	37.19	58.41	1.27	79.50	91.56

Young Sheep III.

Amount consumed as above,	707.20	50.37	75.05	188.19	364.39	29.20
329.87 grams manure excreted,	310.61	40.07	34.42	97.22	131.57	7.33
Grams digested,	396.59	10.30	40.63	90.97	232.82	21.87
Minus hay digested,	272.23	5.63	12.09	91.17	158.75	4.18
Bibby's dairy cake digested,	24.36	4.67	28.54	.80	74.07	17.69
Per cent. digested,	69.51	28.56	67.82	–	86.15	98.88
Average per cent. three sheep digested,	**70.68**	**36.64**	**64.78**	**32.17**	**84.48**	**95.12**

Period VII.

Old Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay,	526.92	33.93	32.88	171.14	277.69	11.28
300 grams beet pulp,	277.86	15.67	27.42	47.71	185.44	1.61
Amount consumed,	804.78	49.60	60.30	218.85	463.13	12.89
271.34 grams manure excreted,	253.84	31.40	27.41	74.15	112.07	8.81
Grams digested,	550.94	18.20	32.89	144.70	351.06	4.08
Minus hay digested,	308.25	7.46	13.97	104.40	177.72	5.25
Beet pulp digested,	241.69	10.74	18.92	40.30	173.34	–
Per cent. digested,	86.98	68.54	69.00	84.47	93.47	–

Old Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	804.78	49.60	60.30	218.85	463.13	12.89
286.94 grams manure excreted,	268.58	33.60	30.11	74.72	120.97	9.19
Grams digested,	536.20	16.00	30.19	144.13	342.16	3.70
Minus hay digested,	308.25	7.46	13.97	104.40	177.72	5.25
Beet pulp digested,	227.95	8.54	16.22	39.73	164.44	–
Per cent. digested,	82.04	54.50	59.15	83.27	88.68	–
Average per cent. two sheep digested,	**84.51**	**61.52**	**64.08**	**83.87**	**91.08**	–

Period VIII.

Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay,	527.10	33.95	32.89	171.20	277.78	11.28
100 grams corn meal,	86.13	1.21	8.50	1.80	70.84	3.77
100 grams Armour's blood meal,	88.70	2.99	84.48	.78	–	.45
Amount consumed,	701.93	38.15	125.87	173.78	348.62	15.50
278.77 grams manure excreted,	260.51	27.72	33.94	82.03	110.17	6.64
Grams digested,	441.42	10.43	91.93	91.75	238.45	8.86
Minus hay digested,	262.97	4.71	12.29	85.57	156.36	4.35
	178.45	5.72	79.64	6.18	82.09	4.51
Minus corn meal digested,	76.66	–	5.95	–	66.59	3.43
Blood meal digested,	101.79	–	73.69	–	15.50	1.08
Per cent. digested,	100.+	–	88.41	–	–	–

Young Sheep II.

Amount consumed as above,	701.93	38.15	125.87	173.78	348.62	15.50
277.21 grams manure excreted,	258.72	27.09	40.28	75.80	109.26	6.29
Grams digested,	443.21	11.06	85.59	97.98	239.36	9.21
Minus hay and corn meal digested,	363.09	7.67	18.36	95.62	166.03	4.98
Blood meal digested,	80.12	3.39	67.23	2.36	73.33	4.23
Per cent. digested,	90.33	–	79.58	–	–	–
Average per cent. two sheep digested,	–	–	**84.00**	–	–	–

Period IX.

Old Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
700 grams English hay,	618.59	39.84	38.59	200.92	326.00	13.24
200 grams soy bean meal,	173.92	9.97	70.77	8.19	48.30	36.70
Amount consumed,	792.51	49.81	109.36	209.11	374.30	49.94
274.77 grams manure excreted,	259.44	33.39	25.48	76.53	115.81	8.22
Grams digested,	533.07	16.42	83.88	132.58	258.49	41.72
Minus hay digested,	361.88	8.76	16.40	122.56	208.64	6.16
Soy bean meal digested,	171.19	7.66	67.48	10.02	49.85	35.56
Per cent. digested,	98.43	76.83	95.35	122.20	103.20	96.89

Old Sheep III.

Amount consumed as above,	792.51	49.81	109.36	209.11	374.30	49.94
306.24 grams manure excreted,	289.73	34.83	30.91	76.95	136.06	10.98
Grams digested,	502.78	14.98	78.45	132.16	238.24	38.96
Minus hay digested,	361.88	8.76	16.40	122.56	208.64	6.16
Soy bean meal digested,	140.90	6.22	62.05	9.60	29.60	32.80
Per cent. digested,	81.01	62.39	87.68	104.90	61.28	89.37
Average per cent. two sheep digested,	**89.72**	**69.61**	**91.51**	**113.55**	**82.24**	**93.13**

Period X.

Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay,	491.15	31.63	30.65	159.53	258.84	10.51
250 grams hominy feed,	221.33	6.97	25.81	12.08	155.17	21.29
Amount consumed,	712.48	38.60	56.46	171.61	414.01	31.80
294.91 grams manure excreted,	277.39	30.46	29.99	82.91	126.13	7.91
Grams digested,	435.09	8.14	26.47	88.70	287.88	23.89
Minus hay digested,	244.93	4.38	11.45	79.73	145.70	4.05
Hominy feed digested,	190.16	3.76	15.02	8.97	142.18	19.84
Per cent. digested,	85.87	53.95	58.19	74.25	91.63	93.19

Young Sheep II.

Amount consumed as above,	712.48	38.60	56.46	171.61	414.01	31.80
291.64 grams manure excreted,	273.50	29.32	30.91	82.27	124.06	6.95
Grams digested,	438.98	9.28	25.55	89.34	289.95	24.85
Minus hay digested,	266.89	7.15	11.56	89.10	154.71	4.64
Hominy feed digested,	172.09	2.13	13.99	.24	135.24	20.21
Per cent. digested,	77.75	30.56	54.20	1.99	87.16	94.88

Young Sheep III.

550 grams English hay,	491.15	–	–	–	–	–
Minus 8.86 grams waste hay,	7.78	–	–	–	–	–
Total hay consumed,	483.37	31.13	30.16	157.00	254.74	10.34
250 grams hominy feed,	221.33	6.97	25.81	12.08	155.17	21.29
Amount consumed,	704.70	38.10	55.97	169.08	409.91	31.63
308.66 grams manure excreted,	290.39	30.84	28.95	88.86	133.99	7.75
Grams digested,	414.31	7.26	27.02	80.22	275.92	23.88
Minus hay digested,	249.08	5.15	11.06	83.41	145.25	3.82
Hominy feed digested,	165.23	2.11	15.96	–	130.67	20.06
Per cent. digested,	74.65	30.27	61.84	–	84.21	94.22
Average per cent. three sheep digested,	**79.42**	**38.26**	**58.08**	**38.12**	**87.67**	**94.10**

Period XI.

Old Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
1,200 grams Eureka silage corn fodder (dry),	480.96	37.76	47.23	157.27	230.38	8.32
Minus 96.86 grams waste,	49.58	4.88	4.54	16.92	22.35	.89
Amount consumed,	431.38	32.88	42.69	140.35	208.03	7.43
166.06 grams manure excreted,	155.83	19.84	18.05	40.58	74.60	2.77
Grams digested,	275.55	13.04	24.64	99.77	133.43	4.66
Per cent. digested,	63.88	39.66	57.72	71.09	64.14	62.72

Old Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
1,200 grams Eureka silage corn fodder (dry),	480.96	37.76	47.23	157.27	230.38	8.32
185.54 grams manure excreted,	174.11	22.27	20.61	44.00	84.08	3.15
Grams digested,	306.85	15.49	26.62	113.27	146.30	5.17
Per cent. digested,	63.80	41.02	56.36	72.02	63.50	62.14
Average per cent. two sheep digested,	**63.84**	**40.34**	**57.04**	**71.56**	**63.82**	**62.43**

Period XII.

Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay,	718.16	46.39	48.40	231.82	374.59	16.95
Minus 48.57 grams waste,	42.26	2.93	2.61	13.83	22.00	.90
Amount consumed,	675.90	43.46	45.79	217.99	352.59	16.05
350.83 grams manure excreted,	327.04	36.37	27.41	106.75	148.28	8.24
Grams digested,	348.86	7.09	18.38	111.24	204.31	7.81
Per cent. digested,	51.61	16.31	40.14	51.03	57.95	48.66

Young Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay,	718.16	46.39	48.40	231.82	374.59	16.95
Minus 32.57 grams waste,	26.27	2.18	1.99	7.84	13.79	.69
Amount consumed,	691.89	44.21	46.41	223.98	360.80	16.26
331.97 grams manure excreted,	308.20	34.55	28.54	97.76	139.43	7.92
Grams digested,	383.69	9.66	17.84	126.22	221.37	8.34
Per cent. digested,	55.46	21.85	38.50	56.35	61.36	51.29
Average per cent. two sheep digested,	**53.54**	**19.08**	**39.32**	**53.69**	**59.66**	**49.98**

Period XXVI. (1903).

Old Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams hay,	577.33	44.05	69.45	182.44	264.94	16.45
250 grams Bibby's dairy cake,	224.50	18.81	48.02	20.63	113.19	23.84
Total consumed,	801.83	62.86	117.47	203.07	378.13	40.29
318.61 grams manure excreted,	294.49	37.93	43.97	80.07	122.57	9.95
Amount digested.	507.34	24.93	73.50	123.00	255.56	30.34
Minus hay digested,	369.49	19.82	43.75	122.23	174.86	8.88
Bibby's dairy cake digested,	137.85	5.11	29.75	.77	80.70	21.46
Per cent. digested,	61.40	27.16	61.95	–	71.29	90.02

Old Sheep II.

Total consumed as above,	801.83	62.86	117.47	203.07	378.13	40.29
271.31 grams manure excreted,	251.40	34.92	37.36	66.72	103.65	8.75
Amount digested,	550.43	27.94	80.11	136.35	274.48	31.54
Minus hay digested,	369.49	19.82	43.75	122.23	174.86	8.88
Bibby's dairy cake digested,	180.94	8.12	36.36	14.12	99.62	22.66
Per cent. digested,	80.59	43.17	75.72	68.44	88.01	95.05

Old Sheep III.

Total consumed as above,	801.83	62.86	117.47	203.07	378.13	40.29
306.77 grams manure excreted,	284.81	39.67	44.40	70.15	119.25	11.34
Amount digested,	517.02	23.19	73.07	132.92	258.88	28.95
Minus hay digested,	369.49	19.82	43.75	122.23	174.86	8.88
Bibby's dairy cake digested,	147.53	3.37	29.32	10.69	84.02	20.07
Per cent. digested,	65.71	17.92	61.06	51.82	74.23	84.19
Average per cent. three sheep digested,	**69.23**	**29.42**	**66.24**	**60.13**	**77.84**	**89.75**

Period XXVIII. (1903).

Old Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams hay,	529.50	40.40	63.70	167.32	242.99	15.09
300 grams hominy meal,	265.44	8.97	32.46	13.19	184.29	26.52
Total consumed,	794.94	49.37	96.16	180.51	427.28	41.61
287.33 grams manure excreted,	267.16	30.22	35.83	76.11	115.76	9.24
Amount digested,	527.78	19.15	60.33	104.40	311.52	32.37
Minus hay digested,	338.88	18.18	40.13	112.10	160.37	8.15
Hominy meal digested,	188.90	.97	20.20	–	151.15	24.22
Per cent. digested,	71.16	10.81	62.23	–	82.02	91.33

Old Sheep II.

Total consumed as above,	794.94	49.37	96.16	180.51	427.28	41.61
262.46 grams manure excreted,	242.88	31.36	34.54	63.12	104.95	8.91
Amount digested,	552.06	18.01	61.62	117.39	322.23	32.70
Minus hay digested,	338.88	18.18	40.13	112.10	160.37	8.15
Hominy meal digested,	213.18	–	21.49	5.29	161.96	24.55
Per cent. digested,	80.31	–	66.20	40.11	87.88	92.57

Old Sheep III.

Total consumed as above,	794.94	49.37	96.16	180.51	427.28	41.61
231.44 grams manure excreted,	215.03	28.08	32.00	51.74	93.34	9.87
Amount digested,	579.91	21.29	64.16	128.77	333.94	31.74
Minus hay digested,	338.88	18.18	40.13	112.10	160.37	8.15
Hominy meal digested,	241.03	3.11	24.03	16.67	173.57	23.59
Per cent. digested,	90.80	34.67	74.03	126.38	94.18	88.95
Average per cent. three sheep digested,	**80.76**	**22.74**	**67.49**	–	**88.03**	**90.95**

Summary of Coefficients (Per Cent.).

RATION.	Sheep Number.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Soy bean fodder,	Old Sheep I.,	63.56	26.29	84.35	39.74	76.09	66.33
	Old Sheep II.,	62.51	16.89	82.12	30.83	79.45	66.00
	Old Sheep III.,	64.53	19.97	82.41	46.13	77.92	63.93
Average,		**63.53**	**21.05**	**82.96**	**38.90**	**77.82**	**65.42**
Eureka silage corn fodder (green).	Old Sheep I.,	64.32	43.10	66.50	56.17	70.26	67.32
	Old Sheep II.,	68.57	41.76	66.85	63.65	74.35	65.68
	Old Sheep III.,	66.99	41.76	67.70	60.97	72.72	64.80
Average,		**66.63**	**42.21**	**67.02**	**60.26**	**72.44**	**65.93**
Eureka silage corn fodder (dry).	Old Sheep II.,	63.88	39.66	57.72	71.09	64.14	62.72
	Old Sheep III.,	63.80	41.02	56.36	72.02	63.50	62.14
Average,		**63.84**	**40.34**	**57.04**	**71.56**	**63.82**	**62.43**
Apple pomace,	Old Sheep I.,	67.39	42.23	–	55.43	82.73	44.21
	Old Sheep II.,	73.64	62.64	–	68.94	85.65	43.50
	Old Sheep III.,	70.77	23.55	–	77.57	84.53	42.51
Average,		**70.60**	**42.81**	–	**67.31**	**84.30**	**43.41**
English hay,	Young Sheep I.,	48.16	11.40	34.59	48.93	54.63	28.42
	Young Sheep II.,	53.22	23.34	36.93	55.34	58.17	37.09
	Young Sheep III.,	51.53	16.55	36.66	53.13	57.02	36.97
Average,		**50.97**	**17.10**	**36.06**	**52.47**	**56.61**	**34.16**
English hay,	Young Sheep I.,	51.61	16.31	40.14	51.03	57.95	48.66
	Young Sheep II.,	55.46	21.85	38.50	56.35	61.36	51.29
Average,		**53.54**	**19.08**	**39.32**	**53.69**	**59.66**	**49.98**
English hay,	Old Sheep II.,	56.91	20.06	41.86	58.28	62.68	47.05
	Old Sheep III.,	60.41	24.25	42.85	63.45	65.60	45.69
Average,		**58.66**	**22.16**	**42.36**	**60.87**	**64.14**	**46.37**
Bibby's dairy cake,	Young Sheep I.,	77.76	44.16	68.11	63.07	87.79	94.91
	Young Sheep II.,	64.78	37.19	58.41	1.27	79.50	91.56
	Young Sheep III.,	69.51	28.56	67.82	–	86.15	98.88
Bibby's dairy cake (1903),	Old Sheep I.,	61.40	27.16	61.95	–	71.29	90.02
	Old Sheep II.,	80.59	43.17	75.72	68.44	88.01	95.05
	Old Sheep III.,	65.71	17.92	61.06	51.82	74.23	84.19
Average,		**69.95**	**33.03**	**65.51**	**46.15**	**81.16**	**92.44**
Alma dried molasses-beet-pulp.	Old Sheep II.,	86.98	68.54	69.00	84.47	93.47	–
	Old Sheep III.,	82.04	54.50	59.15	83.27	88.68	–
Average,		**84.51**	**61.52**	**64.08**	**83.87**	**91.08**	–
Armour's blood meal,	Young Sheep I.,	100.+	–	88.41	–	–	–
	Young Sheep II.,	90.33	–	79.58	–	–	–
Average,		–	–	**84.00**	–	–	–
Medium green soy bean meal.	Old Sheep II.,	98.43	76.83	95.35	122.20	103.20	96.89
	Old Sheep III.,	81.01	62.39	87.68	104.90	61.28	89.37
Average,		**89.72**	**69.61**	**91.51**	**113.55**	**82.24**	**93.13**

Summary of Coefficients (Per Cent.) — Concluded.

RATION.	Sheep Number.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Marshall hominy feed, .	Young Sheep I.,	85.87	53.95	58.19	74.25	91.63	93.19
	Young Sheep II.,	77.75	30.56	54.20	1.99	87.16	94.88
	Young Sheep III.,	74.65	30.27	61.84	–	84.21	94.22
Hominy meal (1903), .	Old Sheep I., .	71.16	10.81	62.23	–	82.02	91.33
	Old Sheep II., .	80.31	–	66.20	40.11	87.88	92.57
	Old Sheep III., .	90.80	34.67	74.03	126.38	94.18	88.95
Average, ...	. . . . .	**80.09**	**32.05**	**62.78**	**60.68**	**87.85**	**92.52**

The Results discussed.

The more important results obtained from the several digestion experiments, the details of which are reported in the previous tables, are discussed as follows: —

Soy Bean Fodder (Brooks Medium Green). — The yield of fodder was light (about 6 tons to the acre), due to the cool summer of 1903. The plants were quite green, thickly set with leaves, well podded and the seed fairly well developed. In common with other legumes at a similar stage of growth, the fodder showed a noticeably high protein percentage, and only moderate quantities of fiber and extract matter. The three sheep ate the fodder readily and digested it quite evenly. Sheep II. refused small quantities of the coarse stems. The results agree fairly well with those already on record.[1]

Summary of Experiment (Per Cent.).

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sheep I., ...	1	1	63.56	26.29	84.35	39.74	76.09	66.33
Sheep II., ...	1	1	62.51	16.89	82.12	30.83	79.45	66.00
Sheep III., ...	1	1	64.53	19.97	82.41	46.13	77.92	63.93
Average, ...	1	3	63.53	21.05	82.96	38.90	77.82	65.42
Average, previous experiments,	5	12	[2]65.00	–	75.00	46.00	75.00	48.00
Clover for comparison, . . .	3	7	66.00	–	70.00	54.00	72.00	64.00
Cow peas for comparison, . .	2	4	[2]68.00	23.00	76.00	60.00	81.00	59.00

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[1] See especially Phelps' work in the reports of the Storrs Experiment Station for 1896 and 1898, and the summary reported in Lindsey's compilation, fourteenth report of the Hatch Experiment Station, p. 198.

[2] Organic matter.

The total dry matter of the soy bean fodder appears to be slightly less digestible than that of other legumes, — clover, Canada field peas and cow peas, — due to its characteristic hard, woody stems. Attention is called to the fact that the digestion coefficient of the fiber in the soy beans is relatively low (39 and 46 per cent.), as compared with those for the clover and cow peas (54 and 60 per cent.). Soy beans will find their chief use in the farm economy as a soiling and silage crop. This subject will be discussed more fully at a later date.

Eureka Silage Corn. — This was a large southern dent variety, 12 to 13 feet tall, which is held in high esteem for silage purposes by the farmers of Worcester County. It is claimed that it will produce several matured ears to each stalk under average summer conditions. The season of 1903 was noticeably cool, and when the corn was cut, September 12–18, it was quite green, the kernels just forming. This variety is being further studied during the present season (1904), and its value as compared with the smaller varieties will be discussed in a subsequent report.

The three sheep showed only slight variations in their ability to digest the corn. The following figures show the average results of all trials with immature dent varieties, as compared with Eureka. The results are quite similar, except that the fiber in case of the Eureka showed a slightly lower digestibility.

Summary of Experiment (Per Cent.).

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Dent corn fodder, immature, . .	4	11	68.00	–	66.00	67.00	71.00	68.00
Eureka (present trial), . . .	1	3	67.00	42.00	67.00	60.00	72.00	66.00

Apple Pomace. — In the sixteenth report of this station (pp. 63–80) are given the results of a digestion test with apple pomace. In that experiment the pomace was fed with a reasonable quantity of hay. In the present trial a smaller amount of hay was fed, and in addition each sheep was given 150 grams of cotton-seed meal, in the hope of increasing the digestibility of the protein in apple pomace.[1] For the sake of comparison, the coefficients obtained in both experiments follow : —

Summary of Experiment (Per Cent.).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Former Experiment, Hay and Pomace.						
Sheep I.,	67.29	42.23	–	55.43	82.73	44.21
Sheep II.,	73.64	62.64	–	68.94	85.65	43.50
Sheep III.,	70.77	23.55	–	77.57	84.53	42.51
Average,	70.60	42.81	–	67.31	84.30	43.41
Present Experiment, Hay, Cotton-seed Meal and Pomace.						
Sheep I.,	65.63	60.91	–	35.82	80.31	51.99
Sheep II.,	71.83	47.20	–	63.93	83.59	39.10
Sheep III.,	80.06	56.11	–	84.95	89.53	50.56
Average,	72.51	54.74	–	61.57	84.48	47.22
Average, both trials,	71.50	48.70	–	64.40	84.40	45.30

Both experiments were made with the same lot of sheep. The sheep digested the total dry matter of the pomace rather more evenly in the present than in the former trial. It is evident that Sheep I. was unable to utilize as much as the other two sheep. It will be seen that the fiber, extract matter and fat, comprising the larger part of the dry matter of the pomace, were digested to approximately the same degree in both experiments. The protein content of the pomace is small, about 1 per cent., and it has not been possible by present methods to fix its digestibility. It probably is digested to a considerable degree, although the results do not make it apparent. The several experiments show the pomace to be as digestible as the better grades of corn silage. Its value for feeding purposes will be further discussed under a separate heading.

English Hay. — The hay used in the present series consisted of a mixture of timothy and redtop, cut in late bloom, and well cured. Two different analyses of this hay are reported in the table of composition. It contained rather less protein and more fiber than the hay usually employed by us for digestion experiments.

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[1] In determining the digestibility of the apple pomace, average digestion coefficients were taken for the cotton-seed meal. See fourteenth report of this station, p. 209.

The young sheep (Period IV.) did not digest the hay as fully as did the old sheep (Period V.) The experiment was repeated with two of the young sheep in Period XII., in which case higher coefficients were obtained, though they did not equal those secured with the old sheep. The hay showed a fair digestibility, and no extreme variations were noted among the several sheep in the same trial. The results, however, do not agree as closely as most of the former experiments with hay carried out at this station.

Bibby's Dairy Cake, made by J. Bibby & Sons of Liverpool, Eng., is composed principally of ground cotton-seed, cereals such as barley and wheat, molasses, fenugreek and salt. It has a pleasing taste and smell, and appears to be highly relished by farm animals. The results of two distinct trials are reported, the first made during the winter of 1903 with three old sheep, and the second made during the winter of 1904 with three young sheep. The first sample was purchased from the stock of a retail grain dealer, and the second was obtained directly from a recent importation. Both lots were in good condition, and resembled each other closely in chemical composition. In the second trial the cake was not relished by Sheep III., although he was induced to eat it after a few days. The cake, which was ground before being fed, acted as a laxative, at first producing soft fæces, which gradually hardened as the period advanced.

Summary of Experiment (*Per Cent.*).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sheep I., old, . . .	61.40	27.16	61.95	–	71.29	90.02
Sheep II., old, . . .	80.59	43.17	75.72	68.44	88.01	95.05
Sheep III., old, . . .	65.71	17.92	61.06	51.82	74.23	84.19
Average, three sheep,	69.23	29.42	66.24	60.13	77.84	89.75
Sheep I., young, . .	77.76	44.16	68.11	63.07	87.79	94.91
Sheep II., young, . .	64.78	37.19	58.41	1.27	79.50	91.56
Sheep III., young, . .	69.51	28.56	67.82	–	86.15	98.88
Average, three sheep,	70.68	36.63	64.78	32.17	84.14	95.11
Average, six sheep, .	69.95	33.02	65.51	46.15	80.99	92.43

Especially wide variations are noted in the case of the old sheep. Sheep II. seemed to have a strong digestion, while Sheep I., judging from the results, was slightly out of condition. Such extreme variations are not apparent in case of the young sheep. In both experiments considerable difficulty was experienced in digesting the crude fiber, due probably to the fact that it was derived largely from cottonseed hulls. The protein was moderately digestible, while the extract matter and fat yielded fairly high coefficients. In general it may be said that the dairy cake was only moderately digested, and possessed a nutritive value similar to standard wheat middlings. An experiment with Bibby's cake fed to four dairy cows has been completed, and the relative commercial and nutritive value of this concentrate will be more fully discussed in that connection.

Dried Molasses-beet-pulp. — This material, manufactured by the Alma Sugar Company of Alma, Mich., consisted of beet pulp and crude molasses dried.[1] In appearance it resembled ordinary black tea. The analysis showed it to be low in protein and high in fiber and extract matter; only traces of fat were found. A more detailed analysis of the product showed that the crude protein consisted of 7.01 per cent. of true albuminoids and 2.90 per cent. of amides; the extract matter contained 13.80 per cent. of cane sugar and 1.83 per cent. of dextrose. The pentosans (18.40 per cent.) were in all probability largely in the form of a hemi-cellulose, and would also be included in the extract matter. The above figures are based on the material in its natural state, with 8.58 per cent. moisture. The results of the experiment with two old sheep follow: —

Summary of Experiment (Per Cent.).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sheep II., ...	86.98	68.54	69.00	84.47	93.47	–
Sheep III., ...	82.04	54.50	59.15	83.27	88.68	–
Average, . . .	84.51	61.52	64.08	83.87	91.08	–
Corn meal for comparison,	89.00	–	70.00	–	94.00	91.00

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[1] See Bulletin No. 99 for a description of the process and a full discussion of its value.

The sheep ate the material readily and digested it without trouble. From the high average digestibility and an experiment with dairy animals elsewhere reported,[1] it is believed the dried pulp has a feeding value about 10 per cent. less than corn meal.

Armour's Blood Meal, especially prepared for cattle feeding, was found to contain 95.24 per cent. of protein and only traces of fat and fiber. Its mechanical condition was all that could be desired. As the detailed experiment shows, it was fed to two young sheep in combination with hay and corn meal. In figuring the digestibility of the blood the coefficients for the corn meal were taken from Lindsey's compilation.[1] The two sheep digested the dry matter of the blood quite thoroughly, namely, 95.14 per cent. The protein was not as thoroughly digested, — 83.99 per cent. ; but this must be more apparent than real, and due to the influence of the other constituents. It is probable that the protein of the hay and corn meal was not quite as thoroughly digested as the coefficients call for, leaving a slight excess undigested, which must of necessity be charged against the blood. This supposition is strengthened by the fact that there is a small plus balance of extract matter and a minus balance of fiber, which show digestible divergences from the established hay and corn meal coefficients. Judging from the digestibility of the dry matter of the blood, we may safely conclude that the blood protein must be quite thoroughly utilized by farm animals. An experiment with dried blood as a source of protein for dairy animals has been completed, and its economic value will be discussed when the results of that experiment are published.

Soy Bean Meal (Brooks Medium Green). — The beans were grown at the station, and coarsely ground before being fed. They were of the usual good quality, containing 40.69 per cent. of protein and 21.10 per cent. fat in dry matter. The coefficients obtained in 1903 follow, and also those secured in the present trial : —

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[1] *Loco citato.*

Summary of Experiment (Per Cent.).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sheep II., old, 1903, ...	95.46	44.93	92.80	194.62	93.04	95.67
Sheep III., old, 1903, ...	87.32	41.70	89.34	85.43	89.29	91.34
Average, ...	91.39	43.32	91.07	140.03	91.17	93.51
Sheep II., old, 1904, ...	98.43	76.83	95.35	122.20	103.20	96.51
Sheep III., old, 1904, ...	81.01	62.39	87.68	104.90	61.28	89.37
Average, ...	89.72	69.61	91.51	113.55	82.24	92.94
Average, four trials, ...	90.56	56.47	91.29	126.79	86.71	93.23
Average, two German trials for comparison,	[1]85.00	–	87.00	–	62.00	94.00

[1] Organic matter.

The soy bean, in common with other concentrates rich in nitrogen, frequently causes digestive irregularities. In the present trial Sheep III. was not able to digest the feed as thoroughly as Sheep II. The same condition was apparent last year, although not quite as marked. It is evident that the beans are as a rule quite thoroughly digested, especially the protein and fat, which are the two important constituents. The coefficients for the fiber are, of course, incorrect, due probably to the favorable influence of the rich protein concentrate in increasing the digestibility of the hay carbohydrates. The small amount of fiber present — about 5 per cent. — renders a knowledge of the exact percentage digestible of minor importance. The extract matter was also largely digested, — probably 80 or more per cent., — although the trials made thus far have not given sufficiently definite results to enable one to fix any exact coefficient.

Hominy Feed, or Chop. — As used for cattle feeding, this consists of the hull, germ, some of the gluten and soft starch. The two samples tested were of good average quality. The results of six trials are presented. Three of them were made with old sheep in 1903, and three with young sheep in 1904.

Summary of Experiment (Per Cent.).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sheep I., old, 1903,	71.16	10.81	62.23	-	82.02	91.33
Sheep II., old, 1903,	80.31	-	66.20	40.11	87.88	92.57
Sheep III., old, 1903,	90.80	34.67	74.03	126.50	88.03	90.95
Average,	80.75	22.74	67.48	-	85.97	91.61
Sheep I., young, 1904,	85.87	53.95	58.19	74.25	91.63	93.19
Sheep II., young, 1904,	77.75	30.56	54.20	1.99	87.16	94.88
Sheep III., young, 1904,	74.65	30.27	61.84	-	84.24	94.22
Average,	79.42	38.26	58.07	38.12	87.66	94.09
Average, both experiments,	80.08	30.50	62.77	-	86.81	92.85
Corn meal for comparison,	89.00	-	70.00	-	94.00	91.00

In the first trial Sheep I. evidently had a somewhat weakened digestion. This condition has already been referred to, and this sheep was dropped during 1904. Sheep III. appeared to have digested the hominy quite thoroughly, while Sheep II. gave results midway between the other two. Just why the three sheep should have shown such variable results with a feed that is supposed to be easily digested, is not clear. In the second trial, with a different sample and with the young sheep, the results also vary more than one would expect. Sheep III. was unable to digest the starchy matter as well as the other two, but made better use of the protein. The percentage of fiber contained in the hominy is relatively small, and the results differ so noticeably that they must be considered worthless. Both lots of sheep utilized the starchy matter and fat to about the same degree; the young sheep failed to digest the protein, as well as the old sheep. The average results of the two experiments must be regarded as giving a fairly good idea of the digestibility of the several fodder groups. It has been assumed hitherto that hominy was as digestible as corn meal; but, in view of the results obtained, this opinion is no longer tenable. The total dry matter of the hominy seems to be about 9 per cent. less digestible than that of the corn. This deficiency apparently falls largely on the protein and extract matter. Corn meal as found upon the market contains on an average 14 per cent. of water, or 1,720 pounds of dry matter to the ton; while hominy shows 9 per cent. of water, or 1,820 pounds of dry matter to the ton. Applying the digestion coefficients for dry matter obtained in both cases, hominy would yield 1,456 pounds and corn meal 1,531 to the ton, and would show the corn meal to be about 5 per cent. more valuable than the hominy. It is proposed to repeat the digestion test with still another sample, and also to compare the two feeds with milch cows. The fact must not be overlooked that different samples of both grains, more particularly the hominy, are likely to vary somewhat in nutritive value, hence too positive conclusions should not be drawn. On the basis of our present knowledge, it may be said that both feeds have similar nutritive values.

Eureka Silage Corn Fodder. — This was a cured sample of the variety previously described. In composition it differed somewhat from the green sample, by containing more ash, noticeably more fiber and less extract matter. Whether this change was the result of sampling, or whether it was brought about by the curing process, it is difficult to say. In case of the green corn, small lots were cut every two or three days during the experiment, each lot being carefully sampled and moisture determinations made immediately. At the end of the trial equal weights of each sample were mixed, and this mixture held to represent the corn fed during the entire experiment. To secure as fair a sample as possible of the material to be cured, a considerable quantity was cut about the middle of the digestion trial with the green corn, and placed in stooks in the field. The stooks were removed to the barn before snow came. In spite of the care taken, differences in the composition of the two lots would be likely to occur. At the time of feeding the cured material, in early March, it still contained 60 per cent. of water. It was finely cut before feeding, and, though somewhat mouldy on the outside, proved to be in fairly good condition. Because of the unexpected large water content, the sheep did not receive a sufficient amount daily, — 1,200 grams, — although the results show that they suffered no great loss in live weight during the period. Sheep III. ate the ration clean, while Sheep II. refused a noticeable amount of the coarser portions. The following figures show the results with the dry fodder; for comparison, the results obtained with the green corn are also stated: —

Summary of Experiment (Per Cent.).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sheep II., old, dry fodder, .	63.88	39.66	57.72	71.09	64.14	62.72
Sheep III., old, dry fodder, .	63.80	41.02	56.36	72.02	63.50	62.14
Average, ...	63.84	40.34	57.04	71.56	63.82	62.43
Sheep I., old, green fodder, .	64.32	43.10	66.50	56.17	70.26	67.32
Sheep II., old, green fodder, .	68.57	41.76	66.85	63.65	74.34	65.68
Sheep III., old, green fodder, .	66.99	41.76	67.70	60.97	72.72	64.80
Average, ...	66.63	42.21	67.02	60.26	72.44	65.93

The coefficients obtained are concordant, and the experiment may be considered quite satisfactory. In comparing the results of the two experiments, it will be noticed that the dry fodder was not as well digested as the green material. This may be accounted for partly on the ground that the sheep received the green fodder in September, after having been at pasture all summer, while the dried material was fed in March, after they had been in similar experiments for six months; and partly because previous experiments have demonstrated that in case of very coarse fodders sheep digest the green substance a little more thoroughly than the cured. For some reason the fiber in the dry material was more fully digested than in the green substance. This may be due to the fact that in the cured fodder some of the extract matter had been converted into a hemi-cellulose, which resisted the action of the chemical solvents, but yielded to the influence of the digestive fluids. In general, it may be said that the results obtained with the Eureka corn compare very favorably with those obtained by other experimenters with the southern varieties at a similar stage of growth.

2. THE DIGESTIBILITY OF GALACTAN.

REPORTED BY J. B. LINDSEY.[1]

Those carbohydrates that can be removed from plants and seeds by the action of dilute mineral acid and alkali, and that are soluble in F. Schulze's reagent, E. Schulze has termed hemi-celluloses. Under this heading he has brought the mother substances, — dextran, levulan, mannan, galactan, araban and xylan; which yield on inversion the sugars, — dextrose, levulose, mannose, galactose, arabinose and xylose. These hemi-celluloses are intermixed with the true celluloses in the cell walls of the plants and seeds. They have been frequently recognized as reserve material, being used by the embryo during the sprouting of the seed. The levulan and mannan have not been found generally distributed, while the araban and xylan (pentosans) constitute fully one-third of the extract matter of all hays and straws, are quite prominent in the hull and bran of most grain seeds, and are even found in the endosperm and cotyledons of many seeds.

Galactan was first extracted from lucerne seeds by Muntz,[2] and was converted into galactose by boiling with dilute acid. E. Schulze[3] and his co-workers found considerable galactan in the seeds of the blue lupine, and as a result assumed that this hemi-cellulose might be very generally distributed in agricultural plants. Lindsey and Holland[4] determined the percentage of galactan in a large number of hays, straws and concentrated feeds. The results of their work showed the presence of quite small amounts of galactan in the non-leguminous plants and seeds. In the leguminous plants from 3 to 4 per cent. was found, while in leguminous seeds the amount varied from 1½ to 14 per cent.

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[1] This experiment was carried out by Mr. E. S. Fulton of the class of 1904 of the Massachusetts Agricultural College, who expressed a desire to undertake work of this character for a graduation thesis. The sheep and apparatus belonging to the department of foods and feeding were placed at his disposal. The digestibility of the hay used had already been determined. Mr. Fulton assumed charge of the sheep, and prepared the fæces for analysis in the station laboratory. The analytical work was done at the college laboratory, under the supervision of Prof. C. Wellington. Mr. Fulton expresses his thanks to Professor Wellington and also to Dr. Lindsey and his co-workers for the many helps and suggestions received.

[2] Bul. Soc. Chem. (2), 37, p. 409.

[3] Zeitsch. f. physiol. Chem. Bd. 14, Heft. 3, Zeitsch. f. physiol. Chem. Bd. 16, Hefts. 4 and 5.

[4] Ninth report of the Hatch Experiment Station, pp. 92-96.

The method[1] employed was the one proposed by Tollens and his pupils, and consisted in principle of oxidizing a given amount of the plant or seed with a solution of slightly diluted nitric acid, and collecting the resulting mucic acid, after further treatment for the removal of impurities, on a tared filter.

No experiments are on record relative to the digestibility of galactan, hence the undertaking of this trial. Alsike clover seed was selected because it contained a noticeable quantity of galactan. It was ground reasonably fine, and fed in connection with hay, the digestibility of which had been previously determined. The experiment was conducted in the usual way, three young Southdown wethers being employed, and passed off without any disturbances.

TABULATED DATA OF THE EXPERIMENT.

Composition of Feed Stuffs (Per Cent.).

[Dry matter.]

FEEDS.	Galactan.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Hay,[2]	1.72	6.53	6.23	33.00	52.27	1.97
Clover seed, . . .	8.07	5.88	34.29	13.12	41.42	5.29

Composition of Fæces (Per Cent.).

[Dry matter.]

Sheep.	FEEDS.	Galactan.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
I., .	Hay and clover seed,	.99	11.57	11.97	29.27	44.43	2.76
II., .	Hay and clover seed,	.95	11.21	13.11	30.23	42.84	2.61
III., .	Hay and clover seed,	1.02	11.32	12.63	28.94	44.49	2.62
I., .	Hay,[2]	.86	11.16	7.86	32.51	45.75	2.72
II., .	Hay, ...	.76	10.70	8.40	31.51	46.74	2.65
III., .	Hay, ...	1.07	10.92	7.97	32.20	46.40	2.51

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[1] *Loco citato.*

[2] The figures for all constituents, excepting galactan, in hay and hay manures were determined in a previous experiment.

Dry Matter Determinations made at the Time of weighing out the Foods, and Dry Matter in Manure excreted, estimated from Air-dry Fæces (Per Cent.).

Sheep.	Feeds.	Hay.	Clover Seed.	Manure.
I., . .	Hay and clover seed, . . .	88.85	91.53	94.05
II., . .	Hay and clover seed, . . .	–	–	93.70
III., . .	Hay and clover seed, . . .	–	–	94.07
I., . .	Hay, ...	–	–	93.36
II., . .	Hay, ...	–	–	93.27
III., . .	Hay, ...	–	–	93.25

Table showing Food fed, Water drank daily, and Daily Amount of Manure excreted.

[Food consumed daily: 600 grams hay, 200 grams clover seed, 5 grams salt.]

DATE.	SHEEP I.			SHEEP II.			SHEEP III.		
	Manure excreted daily (Grams).	Sample Air Dry (Grams).	Water drank daily (Cubic Centimeters).	Manure excreted daily (Grams).	Sample Air Dry (Grams).	Water drank daily (Cubic Centimeters).	Manure excreted daily (Grams).	Sample Air Dry (Grams).	Water drank daily (Cubic Centimeters).
March 20,	922.0	33.24	1,590.0	741.0	29.29	2,290.0	663.0	24.66	2,415.0
" 21,	853.0	29.16	1,060.0	888.0	31.98	1,865.0	879.0	31.60	2,410.0
" 22,	829.0	30.11	1,615.0	938.0	28.55	2,500.0	938.0	33.29	2,425.0
" 23,	799.0	29.56	1,350.0	1,059.0	32.02	2,500.0	822.0	32.29	2,400.0
" 24,	738.0	27.60	1,855.0	852.0	28.14	2,500.0	973.0	33.39	2,500.0
" 25,	909.0	31.64	1,950.0	949.0	29.02	2,500.0	964.0	33.93	2,500.0
" 26,	927.0	33.69	1,750.0	1,316.0	33.50	2,500.0	1,050.0	36.21	2,500.0
Average,	853.9	30.71	1,595.7	963.3	30.36	2,379.3	878.4	32.19	2,450.0

	Pounds.
Weight of Sheep I. at beginning of period,	99.25
Weight of Sheep II. at beginning of period,	94.75
Weight of Sheep III. at beginning of period,	91.50
Weight of Sheep I. at end of period,	99.50
Weight of Sheep II. at end of period,	94.00
Weight of Sheep III. at end of period,	91.00

Sheep I.

	Dry Matter (Per Cent.).	Galactan (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per (Cent.).
600 grams hay fed, ...	533.10	9.17	34.81	33.21	175.92	278.65	10.50
200 grams clover seed, ...	183.06	14.77	10.76	62.77	24.02	75.82	9.68
Total consumed, ...	716.16	23.94	45.57	95.98	199.94	354.47	20.18
307.10 grams manure excreted, . . .	288.83	2.86	33.42	34.57	84.54	128.33	7.97
Grams digested, ...	427.33	21.08	12.15	61.41	115.40	226.14	12.21
Minus hay digested,[1]	265.95	6.90	4.82	12.41	87.93	156.85	4.05
Clover seed digested, ...	161.38	14.18	7.33	49.00	27.47	69.29	8.16
Per cent. digested, ...	88.16	96.01	68.12	78.06	114.36	91.39	84.30

Sheep II.

600 grams hay fed, ...	533.10	9.17	34.81	33.21	175.92	278.65	10.50
200 grams clover seed, ...	183.06	14.77	10.76	62.77	24.02	75.82	9.68
Total consumed, ...	716.16	23.94	45.57	95.98	199.94	354.47	20.18
303.60 grams manure excreted, . . .	284.47	2.70	34.03	37.29	86.00	121.87	7.42
Grams digested, ...	431.69	21.24	11.54	58.69	113.94	232.60	12.76
Minus hay digested,[2]	289.69	7.28	7.87	12.53	98.25	166.55	4.64
Clover seed digested, ...	142.00	13.96	3.67	46.16	15.69	66.05	8.12
Per cent. digested, ...	77.57	94.52	34.11	73.54	65.32	87.11	83.88

Sheep III.

600 grams hay fed, ...	533.10	9.17	34.81	33.21	175.92	278.65	10.50
200 grams clover seed, ...	183.06	14.77	10.76	62.77	24.02	75.82	9.68
Total consumed, ...	716.16	23.94	45.57	95.98	199.94	354.47	20.18
321.90 grams manure excreted, . . .	302.81	3.09	34.28	38.24	87.63	134.72	7.93
Grams digested,[3]	413.35	20.85	11.29	57.74	112.31	219.75	12.25
Minus hay digested, ...	274.71	6.55	5.76	12.17	93.47	158.89	3.88
Clover seed digested, ...	138.64	14.30	5.53	45.57	18.84	60.86	8.37
Per cent. digested, ...	75.74	96.82	51.39	72.60	78.43	80.27	86.47

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[1] Used average coefficient of Sheep I., Periods IV. and XII.

[2] Used average coefficient of Sheep II., Periods IV. and XII.

[3] Used coefficients of Sheep III., Period IV.

SUMMARY OF THE RESULTS.

Composition of the Feeds (Per Cent.).

	Galactan.[1]	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Hay, ...	1.72	6.53	6.23	33.00	52.27	1.97
Clover seed, . . .	8.07	5.88	34.29	13.12	41.42	5.29

Digestibility of the Feeds (Per Cent.).

	Dry Matter.	Galactan.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Hay (all sheep), . .	53.50	75.35	20.50	37.00	55.00	59.00	42.00
Clover seed, Sheep I.,	88.16	96.01	68.12	78.06	114.36	91.39	84.30
Clover seed, Sheep II.,	77.57	94.52	34.11	73.54	65.32	87.11	83.88
Clover seed, Sheep III.,	75.74	96.82	51.39	72.60	78.43	80.27	86.47
Average, . . .	80.49	95.78	51.21	74.73	86.04	86.26	84.55

The analysis and digestibility of the hay were made in connection with a series of digestion experiments at the station. It appeared to contain rather more galactan than other samples examined.[2]

A previous complete analysis of alsike clover seed does not appear to be recorded. It contained a high percentage of protein and a normal amount of galactan.

The results of the digestion experiment with the three sheep show the *total dry matter* of the clover seed meal to have been fairly well digested, although the coefficients are noticeably lower than those on record for soy beans, peas, vetch and lupine (85 to 90 per cent.).

The galactan in the hay is shown to be 75 per cent. digestible. Because of the small quantity present, the results are of minor importance. All three sheep digested the galactan in the clover seed quite thoroughly. Such a result was to have been expected, for the reason that in the seed the galactan is supposed to be comparatively free from incrusting substances, which have been shown by various investigators to seriously interfere with the digestibility of the several fodder groups.[1] Naturally, no positive conclusions should be drawn from the present single investigation. Knowing, however, the physiological and chemical character of the galactan, as well as the digestion coefficients obtained with starch and with the pentosans, — bodies of similar character, — it is reasonably safe to conclude that the results secured give a fairly correct idea of the ability of the animal to utilize the galactan group.

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[1] It may be assumed that the galactan belongs almost wholly to the nitrogen-free extract matter.

[2] Whether the substance obtained was pure galactan, or consisted partly of impurities that it was not possible to remove, it is difficult to say. Lindsey and Holland found a trifle less than 1 per cent. in another sample.

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[1] The pentosans, fifteenth report of the Hatch Experiment Station, p. 118.

3. THE FEEDING VALUE OF APPLE POMACE.

BY J. B. LINDSEY.

There is often considerable discussion in the agricultural press and among farmers concerning the value of apple pomace as a food for dairy and beef cattle; with a view to getting a little positive data, this station instituted a number of experiments, the results of which are here briefly stated.

(*a*) *Composition of Apple Pomace (Per Cent.).*

	Water.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sample I., ...	81.40	.73	.94	3.00	13.03	.90
Sample II., ...	80.20	.60	1.01	3.19	13.73	1.27
Corn silage for comparison,	80.00	1.10	1.70	5.40	11.10	.70

It will be seen from the above figures that apple pomace is a carbohydrate feed similar to corn silage. It contains about the same amount of water (four-fifths), rather less protein and fiber, and a larger proportion of extract matter. Whether the extract matter in the pomace is as valuable, pound for pound, as that contained in the corn, has not been thoroughly demonstrated.

(*b*) *Digestibility of Apple Pomace.*

The value of a feed cannot always be measured by its composition. A food is valuable as a source of nutrition only in so far as its various constituents can be digested and assimilated. This station has made two different experiments to ascertain the digestibility of the pomace, and the detailed results are to be found elsewhere in this report. The summary follows: —

Summary of Experiments (Per Cent.).

	Number of Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Apple pomace (first experiment), . .	3	72.5	54.7	–	61.6	84.5	47.2
Apple pomace (second experiment), . .	3	70.6	42.8	–	67.3	84.3	43.4
Average, ...	6	71.5	48.7	–	64.4	84.4	45.3
Dent corn silage (for comparison), . .	17	64.0	–	52.0	62.0	69.0	85.0
Flint corn silage (small varieties), . .	11	75.0	–	65.0	77.0	79.0	82.0

The results show the total dry matter in apple pomace to be about as digestible as in the best grades of silage. The protein content of the pomace is small, — about 1 per cent., — and it has not been possible by present methods to fix its digestibility. Judging from the composition and digestibility of the pomace, one would feel justified in assuming that, pound for pound, it should approach in feeding value an average quality of corn silage.

(*c*) *Experiments with Dairy Animals.*

While this station has not carried out any exhaustive comparative tests with pomace and other coarse feeds, it has fed the pomace a number of seasons to dairy animals. The material was drawn fresh from the mill, and placed in a large pile under cover. A noticeable quantity of juice gradually drained from it, but it kept in good condition for two months. The animals received from 15 to 30 pounds daily, ate it readily, and the results were quite satisfactory. In one case two cows were fed alternately four weeks at a time on grain and hay, and on grain, hay and pomace; 25 pounds of pomace were compared with 5 pounds of hay. During the pomace period the animals produced 1,153 pounds of milk, and gained 24 pounds in live weight; during the hay period, 1,138 pounds of milk, and lost 6 pounds in weight. On this basis, 5 pounds of pomace were more than equivalent to 1 pound of hay. Judging from this feeding test and from the composition and digestibility of the pomace, it seems probable that 4 pounds, when fed in what is termed a "balanced ration," would be equal in feeding value to 1 pound of good cow hay.

The Vermont Experiment Station has fed apple pomace for four years, using in all twenty cows in the several trials. The pomace was shovelled into the silo, levelled off, and kept in good condition without further care. In some cases it was placed on top of the corn silage after the latter had settled. The quantity fed varied from 10 to 35 pounds daily, with no unfavorable effects. As a result of the several experiments, the Vermont station concludes that the pomace is equivalent in feeding value to an equal weight of average corn silage,[1] and that it is without injurious effect on the flavor of milk and butter.

Farmers are cautioned not to feed too large quantities at first, but to begin with 10 pounds daily, and to gradually increase the quantity to 30 pounds, taking a week or more in which to do it. In this way, danger of a sudden milk shrinkage, or of the animals getting "off feed," as is sometimes reported, may be avoided. Judging from all the data available, it is believed that farmers living in the vicinity of cider mills will find it good economy to utilize the pomace as a food for their dairy stock.

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[1] There is doubt in the mind of the writer whether pomace would prove fully equal to well-preserved and well-eared corn silage; it certainly would approach it in feeding value, and ought to be fully utilized.

4. BLOMO FEED FOR HORSES.

J. B. LINDSEY AND P. H. SMITH.

Blomo feed [1] is a mixture of ground corn stalks, or similar material, with dried blood and refuse molasses. It is almost black in color, slightly sticky to handle, and of a bulky, fibrous nature. It has been extensively advertised as a satisfactory partial oat substitute for horses, and is guaranteed to contain 15 per cent. protein and 1.19 per cent. fat. Feeds of similar character have been in use for some time in Europe.

Composition of Blomo Feed (*Per Cent.*).

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Blomo feed, ...	20.2	9.0	14.7	12.1	43.3	.7
Oats for comparison, .	11.0	2.9	12.9	8.5	59.6	5.1
Corn for comparison, .	11.0	1.4	10.8	1.9	70.2	4.7

It will be seen from the foregoing table that Blomo feed contains more protein and decidedly less fat and starchy matter than either oats or corn. Part of the extract matter consists of cane sugar derived from molasses. The ash content is considerably in excess of either oats or corn.

Digestibility of Blomo Feed.

A digestion experiment [2] was recently completed at this station, with the following results: —

Digestion Coefficients (*Per Cent.*).

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Blomo feed, ...	66.7	31.4	62.7	61.4	76.0	15.3
Oats for comparison, . . .	72.0	33.0	86.0	31.0	79.0	82.0
Corn (cracked) for comparison,	88.0	–	76.0	–	96.0	73.0

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[1] Made by the Blomo Manufacturing Company, New York, N. Y.

[2] With sheep.

Digestible Nutrients in a Ton (Pounds).

	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Total Organic Nutrients.
Blomo feed, ...	184	149	658	2	993
Oats for comparison, . . .	222	53	942	84	1,301
Corn meal for comparison, . .	164	–	1,348	69	1,581

It will be seen that the coefficients obtained from the Blomo are noticeably less than those from either corn or oats. The fat coefficient is of minor importance, because of the small quantity present. It is an established fact that horses digest less fiber than sheep, hence the digestion coefficient for the fiber in the Blomo feed, when applied to horses, is probably too high; a coefficient of 50 would be nearer correct.

Applying the digestion coefficients to the composition of the several feeds, and calculating the digestible organic nutrients in 1 ton, it becomes evident that the Blomo contains some 20 per cent. less digestible organic matter than oats, and some 35 per cent. less than corn. This is due to the comparatively undigestible character of the filler employed.

Cost of Digestible Matter in a Ton.

Allowing $32.50 a ton for Blomo ($1.30 an 80-pound bag), $31 a ton for oats (50 cents a bushel of 32 pounds), and $28 a ton for corn meal, the cost of a pound of digestible matter in each of the several feeds would be as follows: —

	Cents.
Blomo, ...	3.28
Oats, ...	2.40
Corn meal, ...	1.77

At the above prices, it will be seen that digestible matter costs nearly twice as much in the form of Blomo feed as when purchased in corn meal, and about one-third more than in the form of oats.

Feeding Trials with Horses.

Four horses belonging to the agricultural division of the station were employed for the purpose. These horses did hard farm work, which naturally varied somewhat in character and amount from time to time.

TRIAL I.

Object. — The object of the trial was to see if the horses would eat Blomo readily, maintain their weight, and keep in as good working condition as when fed their regular ration.

Rations fed. — The ordinary ration, previous to the beginning of the trial, consisted of 6 quarts of oats, 6 quarts of corn, and what hay the animals would eat clean. The trial ration consisted of 6 quarts of Blomo in place of 6 quarts of oats, 6 quarts of corn, and hay. The Blomo and oats should have been compared pound for pound, but through a misunderstanding they were fed quart for quart, so that 4.2 pounds of Blomo were fed against 6 pounds or more of oats.[1] The horses were gradually placed on the Blomo ration. Three ate it readily, while the fourth refused more or less of it at first, but eventually took the entire quantity without objection.

Duration of the Trial. — The trial began March 19 and lasted until July 5. During this time all four horses were kept constantly on the same ration, and in no case did they fail to take the full quantity of Blomo daily.

Weight and Condition of the Horses. — The horses were weighed two mornings weekly before being fed or watered.

Average Weight at Beginning and End of Trial (Pounds).

1904.	No. 1.	No. 2.	No. 3.	No. 4.
March 19,	1,248	1,288	1,368	1,195
July 5,	1,243	1,270	1,358	1,193

The weight varied slightly from week to week, but it is evident that the ration was sufficient to enable the animals to keep in good condition and do the work required.

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[1] Unfortunately, this department did not have the direct care of the animals, hence could not closely supervise the details of the trial.

While the trial was in progress it was found that the Blomo feed, which had been obtained directly from the manufacturers, was several per cent. below its protein guarantee. They claimed that this was due to carelessness on the part of their chemist, and forwarded another lot, with the request that it be used in place of the first shipment.

TRIAL II.

In the second trial the same horses were used.

Object of the Trial. — The object of the trial was to compare the Blomo feed with oats as a partial grain substitute for work horses.

Plan and Duration of the Trial. — The four horses were divided into lots of two each. In the first half of the trial horses Nos. 1 and 4 received the Blomo ration, and horses Nos. 2 and 3 the oat ration. In the second half these conditions were reversed. Each half lasted six weeks, as follows: —

	Blomo Ration.	Oat Ration.	Length (in Weeks).
July 18 through August 28, .	Horses Nos. 1 and 4,	Horses Nos. 2 and 3,	6
September 5 through October 17,	Horses Nos. 2 and 3,	Horses Nos. 1 and 4,	6

Character of Rations. — The rations were in all cases measured out by the regular feeder. The same misunderstanding existed as in the former trial regarding the relative weight of the Blomo and oats, the feeder giving equal measure instead of weight of each. This resulted in the comparison of approximately 4.2 pounds of Blomo with 6 pounds of oats, which was manifestly unfair to the Blomo.

Blomo Ration fed daily.	*Oat Ration fed daily.*
6 quarts Blomo feed.	6 quarts oats.
6 quarts cracked corn.	6 quarts cracked corn.
Hay (judgment of feeder).	Hay (judgment of feeder).

Weights of Horses (Pounds).

HORSES.	BLOMO.			OATS.		
	Beginning.	End.	Gain or Loss.	Beginning.	End.	Gain or Loss.
No. 1,	1,230	1,245	15+	1,255	1,240	15—
No. 2,	1,295	1,350	55+	1,265	1,290	25+
No. 3,	1,390	1,370	20—	1,325	1,375	50+
No. 4,	1,180	1,205	25+	1,200	1,195	5—
Totals,	5,095	5,170	75+	5,045	5,100	55+

These horses made a slight gain in each case, indicating that both rations were rather more than sufficient to furnish the necessary nutrients for the work performed. Because of the uneven character of the work from day to day, it is not possible to say that one ration gave any better results than the other. It can simply be stated that the horses ate the Blomo ration readily, kept in good condition, and did satisfactory work during the trial.

Keeping Quality of Blomo.

The first lot, of 1 ton, obtained in March, contained 21.5 per cent. of moisture. It was fed gradually until late June, when 480 pounds, or about one-quarter, had spoiled. The second lot, of ½ ton, contained 20 per cent. of water, and was fed from early July until late October, during which time 450 pounds, or nearly one-half, had become sour. This lot underwent a slight decomposition during the warm, muggy weather of August and September. It will be quite necessary for the manufacturers to reduce the moisture content to 12 or less per cent., in order to prevent such changes, especially during the warm season.

Conclusions.

1. Blomo feed was eaten readily, excepting that one of the horses objected to it during the first week of the trial.

2. Considerable of the Blomo spoiled on being kept during the warm weather, and it will be necessary for the manufacturers to reduce the moisture content, in order to overcome this difficulty.

3. It contained noticeably less digestible matter than corn or oats, and, at prices usually prevailing, the nutritive matter it contains must be regarded as decidedly expensive.

4. No injurious effect was noted from feeding a considerable quantity of Blomo as a component of the daily ration during a period of seven months. The horses kept in good condition and did satisfactory work.

5. Owing to a misunderstanding, whereby the Blomo and oats were fed measure for measure, instead of weight for weight, it was not possible to directly compare the feeding value of these two feeds.

6. No particular advantage is to be gained from the use of Blomo feed, other than securing a change from the regular corn and oat diet.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.
Assistants: HENRI D. HASKINS, RICHARD H. ROBERTSON,[1] EDWARD G. PROULX.

PART I. — Report on Official Inspection of Commercial Fertilizers.
PART II. — Report on General Work in the Chemical Laboratory.

PART I. — REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS DURING THE SEASON OF 1904.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 66; of these, 38 have offices for the general distribution of their goods in Massachusetts, 8 in New York, 8 in Connecticut, 3 in Vermont, 2 in Pennsylvania, 2 in Ohio, 1 in Rhode Island, 1 in Canada, 1 in New Jersey, 1 in Maryland and 1 in Arkansas.

Three hundred and twenty-nine brands of fertilizers and agricultural chemicals have been licensed in Massachusetts during the year. Five hundred and seventy-six samples of fertilizers have been collected up to the present time, in our general markets by experienced assistants in the station. Five hundred and twenty-five samples were analyzed at the beginning of December, 1904, representing 295 distinct brands of fertilizers. These analyses were published in two bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 100, July, and No. 102, November, 1904. Other official samples not included in these two bulletins will be reserved for our next publication in March, 1905. By comparing the above statements with those of our previous annual reports, it will be seen that there is a gradual increase in the number of fertilizers that are licensed in the State of Massachusetts from year to year. This fact would tend to show an increased consumption of these articles, and would emphasize the importance of their annual inspection from a commercial agricultural standpoint. Twenty-three more brands of fertilizers have been licensed during the past season than in the previous year.

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[1] Died Sept. 10, 1904.

The following table gives in compact form an abstract of the results of analyses of official commercial fertilizers: —

	1903.	**1904.**
(*a*) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee,	7	7
Number with two elements above the highest guarantee, . . .	19	32
Number with one element above the highest guarantee, ...	91	111
Number with three elements between the lowest and highest guarantee,	207	190
Number with two elements between the lowest and highest guarantee,	118	146
Number with one element between the lowest and highest guarantee, .	42	48
Number with three elements below the lowest guarantee, . . .	2	none
Number with two elements below the lowest guarantee, ...	24	12
Number with one element below the lowest guarantee, ...	100	103
(*b*) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee, . . .	2	8
Number with one element above the highest guarantee, ...	17	16
Number with two elements between the lowest and highest guarantee,	31	20
Number with one element between the lowest and highest guarantee, .	13	19
Number with two elements below the lowest guarantee, ...	1	1
Number with one element below the lowest guarantee, ...	14	15
(*c*) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee, ...	11	16
Number between the lowest and highest guarantee, ...	13	24
Number below the lowest guarantee, ...	18	13

From the above table it will be seen that, on the whole, the quality of the fertilizers that have been licensed, collected and examined during the past year is higher than in the previous season of 1903.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1903 and 1904 (Cents per Pound).

	1903.	1904.
Nitrogen in ammonia salts,	17.50	17.50
Nitrogen in nitrates,	15.00	16.00
Organic nitrogen in dry and fine-ground fish, meat, blood, and in high-grade mixed fertilizers.	17.00	17.50
Organic nitrogen in fine bone and tankage,	16.50	17.00
Organic nitrogen in medium bone and tankage,	12.00	12.50
Phosphoric acid soluble in water,	4.50	4.50
Phosphoric acid soluble in ammonium citrate,	4.00	4.00
Phosphoric acid in fine-ground fish, bone and tankage,	4.00	4.00
Phosphoric acid in cotton-seed meal, castor pumace and wood ashes,	4.00	4.00
Phosphoric acid in coarse fish, bone and tankage,	3.00	3.00
Phosphoric acid insoluble (in water and ammonium citrate) in mixed fertilizers.	2.00	2.00
Potash as sulfate (free from chloride),	5.00	5.00
Potash as muriate,	4.25	4.25

A comparison of the market costs of the different essential ingredients of plant food for 1904 with the previous year shows the following variation: nitrogen in the form of nitrates is a cent higher per pound; the higher grades of organic nitrogen, including nitrogen classed in high-grade mixed fertilizers, are half a cent higher in cost than for the year 1903; the cost of the different forms of phosphoric acid and potassium oxide remains the same as in the previous year.

As in the past, the above schedule of trade values was adopted by representatives of the Massachusetts, Connecticut, Rhode Island, Maine, Vermont and New Jersey experiment stations, at a conference held during the month of March, 1904, and is based upon the quotations in ton lots of the leading standard raw materials furnishing nitrogen, phosphoric acid and potash, and which go to make up the bulk of our commercial fertilizers. These quotations are taken from the fertilizer markets in centres of distribution in New England, New York and New Jersey during the six months preceding March, 1904.

Table A, on the following page, gives the average analysis of officially collected fertilizers for 1904; Table B gives a compilation of analyses, showing the maximum, minimum and average percentages of the different essential ingredients of plant food found in the special crop fertilizers, so called, put out by the different manufacturers during the season of 1904.

TABLE A. — *Average Analysis of Officially Collected Fertilizers for 1904 (Per Cent.).*

NATURE OF MATERIAL.	Moisture.	NITROGEN IN ONE HUNDRED POUNDS.		PHOSPHORIC ACID IN ONE HUNDRED POUNDS.							POTASSIUM OXIDE IN ONE HUNDRED POUNDS.	
							TOTAL.		AVAILABLE.			
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
Complete fertilizers,	10.67	2.96	2.73	4.30	3.66	2.87	10.60	9.11	7.89	7.55	5.47	5.22
Ground bones,	8.70	3.32	2.93	.42	7.37	16.12	23.91	22.24	7.80	8.39	–	–
Tankage,	10.39	7.02	5.49	–	5.11	5.10	10.21	15.20	5.26	–	–	–
Dry ground fish,	9.82	8.44	8.19	–	5.08	3.76	8.84	7.20	5.08	–	–	–
Dissolved bone-black,	10.92	–	–	12.81	3.00	1.70	17.51	15.50	15.81	15.00	–	–
Acid phosphate,	10.92	–	–	10.33	4.46	1.69	16.48	13.90	14.79	12.33	–	–
Wood ashes,	15.98	–	–	–	–	–	1.52	1.10	–	–	4.59	4.83
Cotton-seed meal,	7.44	6.79	7.00	–	–	–	–	–	–	–	–	–
Flax meal,	8.84	5.89	6.08	–	–	–	–	–	–	–	–	–
Nitrate of soda,	1.76	15.34	15.43	–	–	–	–	–	–	–	–	–
Sulfate of ammonia,	.13	20.20	19.00	–	–	–	–	–	–	–	–	–
High-grade sulfate of potash,	.49	–	–	–	–	–	–	–	–	–	49.65	48.00
Muriate of potash,	1.47	–	–	–	–	–	–	–	–	–	50.69	50.00
Dried blood,	15.13	10.80	6.78	–	–	–	–	–	–	–	–	–

TABLE B. — *Compilation of Analyses of Commercial Fertilizers for the Year 1904 (Per Cent.).*

NAME OF FERTILIZER.	Moisture.	NITROGEN IN ONE HUNDRED POUNDS.			TOTAL PHOSPHORIC ACID IN ONE HUNDRED POUNDS.			AVAILABLE PHOSPHORIC ACID IN ONE HUNDRED POUNDS.			POTASSIUM OXIDE IN ONE HUNDRED POUNDS.		
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
Corn fertilizer,	11.33	5.38	1.12	2.34	14.82	8.72	11.03	10.76	5.36	8.44	8.96	1.54	3.53
Fruit and vine fertilizer,	11.29	3.86	2.46	3.02	13.02	7.82	9.53	9.26	7.08	7.23	11.08	5.62	8.42
Grain fertilizer,	9.67	7.81	.84	2.65	11.06	8.12	9.77	9.01	4.57	6.58	10.40	.88	3.82
Grass fertilizer,	7.83	5.31	2.49	4.08	14.71	5.06	9.14	13.03	2.68	6.81	11.94	2.20	5.33
Market-garden fertilizer,	11.53	4.09	1.73	2.87	11.54	8.65	10.56	9.09	6.91	8.18	10.00	2.08	6.18
Potato fertilizer,	11.38	4.68	1.71	2.63	14.44	6.93	10.27	12.58	4.12	8.08	10.08	2.58	5.64
Tobacco fertilizer,	10.14	5.97	.66	4.04	14.96	5.50	10.20	11.42	1.76	6.59	15.06	.72	8.13
Onion fertilizer,	10.95	3.42	1.61	3.02	12.18	8.24	9.88	8.93	6.84	7.97	10.48	6.78	7.78

A study of Table B teaches the same lessons as in the past. It is a much safer plan to study our fertilizer bulletins, when selecting a supply of commercial fertilizers, than to depend upon mere trade names. Oftentimes the fertilizer costing the most per ton is the cheapest and most economical fertilizer to use if applied to the soil intelligently. Every farmer should know the requirements of his soil, in order to judiciously select his supply of fertilizers. No iron-clad rule can be laid down for selecting fertilizers, as conditions vary so widely on different soils; it is safe to say, however, that for general use those fertilizers should be purchased which furnish the greatest amount of the three essential elements of plant food in a suitable and available form for the same money.

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State during the Past Year (May 1, 1904, to May 1, 1905), and the Brands licensed by Each.

The American Agricultural Chemical Co., Boston, Mass.: —
- Brightman's Fish and Potash.
- Double Manure Salt.
- Dissolved Bone-black.
- Dried Blood.
- Dry Ground Fish.
- Fine-ground Bone.
- Fine-ground Tankage.
- Grass and Lawn Top-dressing.
- Ground South Carolina Phosphate.
- High-grade Fertilizer with Ten Per Cent. Potash.
- High-grade Sulfate of Potash.
- Kainit.
- Muriate of Potash.
- Nitrate of Soda.
- Plain Superphosphate.
- Tobacco Starter and Grower.

The American Agricultural Chemical Co. (Bradley Fertilizer Co., branch), Boston, Mass.: —
- Abattoir Bone Dust.
- Bradley's Complete Manure for Corn and Grain.
- Bradley's Complete Manure for Onions.
- Bradley's Complete Manure for Potatoes and Vegetables.
- Bradley's Complete Manure for Top-dressing Grass and Grain.
- Bradley's Complete Manure with Ten Per Cent. Potash.
- Bradley's Corn Phosphate.
- Bradley's Eclipse Phosphate.

The American Agricultural Chemical Co. (Bradley Fertilizer Co., branch), Boston, Mass. — *Con.*
- Bradley's English Lawn Fertilizer.
- Bradley's Niagara Phosphate.
- Bradley's Potato Fertilizer.
- Bradley's Potato Manure.
- Bradley's Seeding-down Manure.
- Bradley's X L Superphosphate.
- Columbia Fish and Potash.
- Church's Fish and Potash.

The American Agricultural Chemical Co. (H. J. Baker & Bro., branch), New York, N. Y.: —
- Baker's A A Ammoniated Phosphate.
- Baker's Complete Potato Manure.

The American Agricultural Chemical Co. (Clark's Cove Fertilizer Co., branch), Boston, Mass.: —
- Clark's Cove Bay State Fertilizer.
- Clark's Cove Bay State Fertilizer, G G.
- Clark's Cove Great Planet Manure.
- Clark's Cove King Philip Guano.
- Clark's Cove Potato Fertilizer.
- Clark's Cove Potato Manure.

The American Agricultural Chemical Co. (Crocker Fertilizer and Chemical Co., branch), Buffalo, N. Y.: —
- Crocker's A A Complete Manure.
- Crocker's Corn Phosphate.
- Crocker's Potato, Hop and Tobacco Phosphate.

The American Agricultural Chemical Co. (Cumberland Bone Phosphate Co., branch), Boston, Mass.: —
- Cumberland Potato Fertilizer.
- Cumberland Superphosphate.

The American Agricultural Chemical Co. (L. B. Darling Fertilizer Co., branch), Pawtucket, R. I.: —
- Darling's Blood, Bone and Potash.
- Darling's Complete Ten Per Cent. Manure.
- Darling's Farm Favorite.
- Darling's General Fertilizer.
- Darling's Potato and Root Crop Manure.
- Darling's Potato Manure.
- Darling's Tobacco Grower.

The American Agricultural Chemical Co. (Great Eastern Fertilizer Co., branch), Rutland, Vt.: —
- Garden Special.
- General Fertilizer.
- Grass and Oats Fertilizer.
- Northern Corn Special.
- Vegetable, Vine and Tobacco.

The American Agricultural Chemical Co. (Pacific Guano Co., branch), Boston, Mass.: —
- Pacific High-grade General.
- Pacific Nobsque Guano.
- Pacific Potato Special.
- Soluble Pacific Guano.

The American Agricultural Chemical Co. (Packers' Union Fertilizer Co., branch), Rutland, Vt.: —
- Animal Corn Fertilizer.
- Gardener's Complete Manure.
- Potato Manure.
- Universal Fertilizer.
- Wheat, Oats and Clover Fertilizer.

The American Agricultural Chemical Co. (Quinnipiac Co., branch), Boston, Mass.: —
- Quinnipiac Climax Phosphate.
- Quinnipiac Corn Manure.
- Quinnipiac Havana Tobacco Fertilizer.
- Quinnipiac Market-garden Manure.
- Quinnipiac Onion Manure.
- Quinnipiac Phosphate.
- Quinnipiac Potato Manure.
- Quinnipiac Potato Phosphate.

The American Agricultural Chemical Co. (Read Fertilizer Co., branch), New York, N. Y.: —
- Read's Farmers' Friend.
- Read's High-grade Farmers' Friend.
- Read's Practical Potato Special.
- Read's Standard.
- Read's Vegetable and Vine.

The American Agricultural Chemical Co. (Standard Fertilizer Co., branch), Boston, Mass.: —
- Standard Complete Manure.
- Standard Fertilizer.
- Standard Guano.
- Standard Special for Potatoes.

The American Agricultural Chemical Co. (Henry F. Tucker Co., branch), Boston, Mass.: —
- Tucker's Original Bay State Bone Superphosphate.
- Tucker's Special Potato Fertilizer.

The American Agricultural Chemical Co. (Williams & Clark Fertilizer Co., branch), Boston, Mass: —
- Williams & Clark's Americus Phosphate.
- Williams & Clark's Corn Phosphate.
- Williams & Clark's High-grade Special.
- Williams & Clark's Potato Manure.
- Williams & Clark's Potato Phosphate.
- Williams & Clark's Prolific Crop Producer.
- Williams & Clark's Royal Bone Phosphate.

The American Agricultural Chemical Co. (M. E. Wheeler & Co., branch), Rutland, Vt.: —
- Corn Fertilizer.
- Bermuda Onion Grower.
- Grass and Oats Fertilizer.
- Havana Tobacco Fertilizer.
- Potato Manure.

W. H. Abbott, Holyoke, Mass.: —
- Animal Fertilizer.
- Eagle Brand.
- Tobacco Fertilizer.

The Abbott & Martin Rendering Co., Columbus, O.: —
- Abbott's Tobacco and Potato Special.
- Harvest King.
- Ideal Grain Grower.

The American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.
- Cotton-seed Hull Ashes.

American Linseed Co., New York, N. Y.: —
- Cleveland Flax Meal.

Armour Fertilizer Works, Baltimore, Md.: —
- All Soluble.
- Ammoniated Bone with Potash.
- Bone Meal.
- Blood, Bone and Potash.
- Grain Grower.
- High-grade Potato.

H. J. Baker and Bro., New York, N. Y.: —
- Castor Pumace.

Beach Soap Co., Lawrence, Mass.: —
- Beach's Advance Brand.
- Beach's Fertilizer Bone.
- Beach's Reliance.
- Beach's Universal.

Berkshire Fertilizer Co., Bridgeport, Conn.: —
- Berkshire Complete Fertilizer.
- Berkshire Ammoniated Bone Phosphate.
- Berkshire Potato and Vegetable Phosphate.

Joseph Breck & Sons, Boston, Mass.: —
- Breck's Lawn and Garden Dressing.
- Breck's Market-garden Manure.

Bowker Fertilizer Co., Boston, Mass.: —
- Bone, Blood and Potash.
- Bowker's Ammoniated Food for Flowers.
- Bowker's Bone and Wood Ash Fertilizer.
- Bowker's Complete Mixture.
- Bowker's Double Manure Salts.
- Bowker's Farm and Garden Phosphate.
- Bowker's Fish and Potash (Square Brand).
- Bowker's Ground Bone.
- Bowker's High-grade Fertilizer.
- Bowker's Hill and Drill Phosphate.
- Bowker's Kainit.
- Bowker's Lawn and Garden Dressing.
- Bowker's Potato and Vegetable Fertilizer.
- Bowker's Potash Bone.
- Bowker's Market-garden Fertilizer.
- Bowker's Potato and Vegetable Phosphate.
- Bowker's Soluble Animal Fertilizer.
- Bowker's Special Onion Manure.
- Bowker's Superphosphate.
- Bowker's Sure Crop Phosphate.
- Bowker's Tankage.
- Bowker's Ten Per Cent. Manure.
- Bowker's Tobacco Ash Fertilizer.
- Bowker's Tobacco Starter.
- Bristol Fish and Potash.
- Corn Phosphate.
- Dissolved Bone-black.
- Dried Blood.
- Early Potato Manure.
- Fine Dry Ground Fish.
- Fish and Potash (D Brand).
- Gloucester Fish and Potash.
- Muriate of Potash.
- Nitrate of Soda.
- Stockbridge Special Manures.
- Sulfate of Ammonia.

Bowker Fertilizer Co., Boston, Mass. — *Con.*
- Sulfate of Potash.
- Tobacco Ash Elements.
- Wood Ashes.

T. H. Bunch, Little Rock, Ark.: —
- Cotton-seed Meal.

Charles M. Cox & Co., Boston, Mass.: —
- Cotton-seed Meal.

Chicopee Rendering Co., Springfield, Mass.: —
- Pure Ground Bone.
- Complete Animal Fertilizer.
- Lawn and Garden Dressing.
- Tankage.

E. Frank Coe Co., New York, N. Y.: —
- American Farmers' Ammoniated Bone.
- American Farmers' Complete Manure.
- American Farmers' Corn King.
- American Farmers' Grass and Grain.
- American Farmers' Market-garden Special.
- Columbian Corn Fertilizer.
- Columbian Potato Fertilizer.
- E. Frank Coe's F P Fish and Potash.
- E. Frank Coe's Gold Brand Excelsior Guano.
- E. Frank Coe's High-grade Ammoniated Bone Superphosphate.
- E. Frank Coe's Nitrate of Soda.
- E. Frank Coe's Tobacco and Onion Fertilizer.
- Celebrated Special Potato.
- Excelsior Potato Fertilizer.
- New Englander Corn Fertilizer.
- New Englander Potato Fertilizer.
- Red Brand Excelsior Guano.
- X X X Ground Bone.

John C. Dow & Co., Boston, Mass.: —
- Dow's Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
- Imperial Grass Fertilizer.
- Imperial Plant Food.

William E. Fyfe & Co., Clinton, Mass.: —
- Canada Unleached Hard-wood Ashes.

R. & J. Farquhar & Co., Boston, Mass.: —
- Clay's London Fertilizer.
- Thompson's Improved Vine, Plant and Vegetable Manure.

Hargraves Soap Co., Fall River, Mass.: —
- Ground Bone Fertilizer.

The Hardy Packing Co., Columbus, O.: —
- Hardy's Complete Manure.
- Hardy's Tankage, Bone and Potash.
- Hardy's Tobacco and Potato Special.

C. W. Hastings, Cambridgeport, Mass.: —
- Ferti Flora.

Thomas Hersom & Co., New Bedford, Mass.: —
- Bone Meal.
- Meat and Bone.

John Joynt, Lucknow, Can.: —
- Pure Canada Unleached Hard-wood Ashes.

Lister's Agricultural Chemical Works, Newark, N. J.: —
- Lister's Animal Bone and Potash.
- Lister's High-grade Special.
- Lister's Oneida Special.
- Lister's Potato Manure.
- Lister's Special Corn.
- Lister's Special Potato.
- Lister's Success Fertilizer.

Lowell Fertilizer Co., Boston, Mass.: —
- Acid Phosphate.
- Muriate of Potash.
- Nitrate of Soda.
- Swift's Lowell Animal Brand.
- Swift's Lowell Bone Fertilizer.
- Swift's Lowell Dissolved Bone and Potash.
- Swift's Lowell Dissolved Bone-black.
- Swift's Lowell Empress Brand.
- Swift's Lowell Ground Bone.
- Swift's Lowell Lawn Dressing.
- Swift's Lowell Market Garden.
- Swift's Lowell Potato Manure.
- Swift's Lowell Potato Phosphate.
- Swift's Lowell Tankage.

George E. Marsh & Co., Lynn, Mass.: —
- Pure Bone Meal.

Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
- Average Soil Complete Manure.
- Cauliflower and Cabbage Manure.
- Complete Manure (A Brand).
- Complete Manure for General Use.
- Complete Manure Ten Per Cent. Potash.
- Corn Manure.
- Economical Potato Manure.
- Fruit and Vine Manure.
- Grass and Grain Spring Top-dressing.
- Lawn Top-dressing.
- Potato Manure.
- Tobacco Ash Constituents.
- Tobacco Manure Wrapper Brand.
- Tobacco Starter Improved.
- Top-dressing Improved, One-half Strength.
- Vegetable Manure or Complete Manure for Light Soils.

D. M. Moulton, Monson, Mass.: —
- Ground Bone.

National Fertilizer Co., Bridgeport, Conn.: —
- Chittenden's Ammoniated Bone.
- Chittenden's Complete Fertilizer.
- Chittenden's Fish and Potash.
- Chittenden's High-grade Special.
- Chittenden's Market Garden.
- Chittenden's Potato Phosphate.
- Chittenden's Tobacco Manure.

New England Fertilizer Co., Boston, Mass.: —
- Corn Phosphate.
- Potato Fertilizer.
- Superphosphate.

Olds & Whipple, Hartford, Conn.: —
- Complete Tobacco Fertilizer.
- Vegetable Potash.

R. T. Prentiss, Holyoke, Mass.: —
- Complete Fertilizer.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
- A A Brand.
- Acid Phosphate.
- Lawn Dressing.
- Grain Grower.
- Muriate of Potash.
- Nitrate of Soda.
- P. & P. Potato.
- Plymouth Rock Brand.
- Special Fertilizer for Strawberries.
- Special Potato.
- Sulfate of Potash.

Jacob Reese, Darby, Penn.: —
- Odorless Slag Phosphate.

Rogers & Hubbard Co., Middletown, Conn.: —
- Hubbard's All Soils and All Crops Fertilizer.
- Hubbard's Corn Phosphate.
- Hubbard's Grass and Grain Fertilizer.
- Hubbard's Oats and Top-dressing.
- Hubbard's Potato Phosphate.
- Hubbard's Pure Raw Knuckle Bone Flour.
- Hubbard's Soluble Corn.
- Hubbard's Soluble Potato Manure.
- Hubbard's Soluble Tobacco Manure.
- Hubbard's Strictly Pure Fine Bone.

Rogers Manufacturing Co., Rockfall, Conn.: —
- All Round Fertilizer.
- Complete Corn and Onion.
- Complete Fish and Potash.

Rogers Manufacturing Co., Rockfall, Conn. — *Con.*
- Complete Potato and Vegetable.
- High-grade Grass and Grain.
- High-grade Oats and Top-dressing.
- High-grade Tobacco and Potato.
- High-grade Soluble Tobacco.
- Nitrate of Soda.
- Pure Fine-ground Bone.

Ross Bros., Worcester, Mass.: —
- Ross Brother's Lawn Dressing.

N. Roy & Son, South Attleborough, Mass.: —
- Complete Animal Fertilizer.

Russia Cement Co., Gloucester, Mass.: —
- Essex Complete Manure for Corn, Grain and Grass.
- Essex Complete Manure for Potatoes, Roots and Vegetables.
- Essex Corn Fertilizer.
- Essex Dry Ground Fish.
- Essex A I Superphosphate.
- Essex Market Garden and Potato Manure.
- Essex Odorless Lawn Dressing.
- Essex Rhode Island Special for Potatoes and Roots.
- Essex Special Tobacco Manure.
- Essex Tobacco Starter.
- Essex X X X Fish and Potash.
- Muriate of Potash.
- Nitrate of Soda.

Salisbury Cutlery Handle Co., Salisbury, Conn.: —
- Fine Bone.

M. L. Shoemaker & Co., Limited, Philadelphia, Penn.: —
- Swift Sure Superphosphate for General Use.
- Swift Sure Bone Meal.

Sanderson's Fertilizer and Chemical Co., New Haven, Conn.: —
- Sanderson's Corn Superphosphate.
- Sanderson's Fine-ground Fish.
- Sanderson's Formula A.
- Sanderson's Formula B.
- Sanderson's Sulfate of Potash.
- Sanderson's Potato Manure.
- Sanderson's Special with Ten Per Cent. Potash.
- Sanderson's Top-dressing for Grass and Grain.

Thomas L. Stetson, Randolph, Mass.: —
- Bone Meal.

J. Stroup, Son & Co., Boston, Mass.: —
- Canada Hard-wood Unleached Ashes.

A. L. Warren, Northborough, Mass.: —
- Warren's Ground Bone.

The Whitman & Pratt Rendering Co., Lowell, Mass.: —
- Whitman & Pratt's All Crops.
- Whitman & Pratt's Corn Success.
- Whitman & Pratt's Potato Plowman.
- Whitman & Pratt's Pure Ground Bone.

Wilcox Fertilizer Works, Mystic, Conn.: —
- Complete Bone Superphosphate.
- Dry Ground Fish.
- Fish and Potash.
- High-grade Tobacco Special.
- Potato Fertilizer.
- Potato, Onion and Vegetable.

Sanford Winter, Brockton, Mass.: —
- Pure Fine-ground Bone.

J. M. Woodard & Bro., Greenfield, Mass.: —
- Tankage.

A. H. Wood & Co., Framingham, Mass.: —
- A A Brand.
- B B Brand.
- C C Brand.

PART II. — REPORT ON GENERAL WORK IN THE CHEMICAL LABORATORY.

C. A. GOESSMANN.

1. Analyses of materials forwarded for examination.
2. Notes on wood ashes and lime ashes.
3. Notes on phosphatic slag and experiments with native phosphates.

1. ANALYSES OF MATERIALS FORWARDED FOR EXAMINATION.

This department of our work has been of the same general character as in past years. We have received during the season 283 samples of miscellaneous substances from farmers within our State for analysis; this is 48 more than was received during the season of 1903.

As far as time and facilities permit, we have devoted our attention to the examination of this class of materials, the substances being taken up for analysis in the order of their arrival at this office. During the season of the official inspection of commercial fertilizers, April 1 to November, our time is so completely occupied that work in this class of general materials, for the benefit of individual farmers, has to give place, in a measure, to the control work of inspection. For this reason we would urge those sending samples for free analysis to forward them, so far as possible, between November 1 and April 1, thus insuring more prompt reports in results of analysis.

As in the past, we have taken an active part in the technical work of the Association of Official Agricultural Chemists for the establishment of new methods of analysis. Many determinations were made on samples forwarded by the association to test the efficacy of several new methods of determining potash and the various forms of phosphoric acid.

Following is a list of materials forwarded by farmers and agricultural organizations during the season of 1904 : —

Wood ashes,	50
Soils,	47
Complete fertilizers,	32
Lime ashes,	14
Tankage,	10
Ground bone,	9
Nitrate of soda,	8
Miscellaneous substances,	9
Low-grade sulfate of potash,	7
Muck,	7
Meadow mud,	7
Cotton-seed meal,	6
Dry ground fish,	5
Mill refuse,	5
Manure,	5
Acid phosphate,	4
Peat,	4
Cotton-hull ashes,	3
Muriate of potash,	3
Lime,	3
Dissolved bone-black,	3
Cotton-seed droppings,	2
Cotton-seed dust,	2
Sulfate of ammonia,	2
Carbonate of potash,	2
Phosphatic slag,	2
Steamed bone,	2
Wool dust,	2
Wool waste,	2
Dried blood,	2
Sewage,	2
Pulp ashes,	1
Cotton compost,	1
Carbonate of potash-magnesia,	1
Silicate of potash,	1
High-grade sulfate of potash,	1
Nitrate of potash,	1
Belgian phosphate,	1
Raw bone,	1
Dissolved bone,	1
Lime and nitrate of soda,	1
Guinea pig manure,	1
Liquid manure,	1
Sheep manure,	1
Lime refuse from tannery,	1
Waste lime,	1
Granulated lime,	1
Plaster,	1
Raw hide dust,	1
Cocoa shells,	1
Dandelion roots,	1
Clover roots,	1

2. NOTES ON WOOD ASHES AND LIME ASHES.

(*a*) *Wood Ashes.* — Seventeen and one-half per cent. of the materials forwarded for analysis during the season have been wood ashes, being about the same proportion as that for the year 1903. The following abstract of results of analysis shows their general chemical character, also a comparison in results of analysis with the previous year 1903 : —

Analysis of Wood Ashes.

	NUMBER OF SAMPLES.	
	1903.	**1904.**
Moisture from 1 to 10 per cent.,	11	18
Moisture from 10 to 20 per cent.,	14	16
Moisture from 20 to 30 per cent.,	9	8
Moisture above 30 per cent.,	3	3
Potassium oxide above 8 per cent.,	2	2
Potassium oxide from 6 to 7 per cent.,	4	8
Potassium oxide from 5 to 6 per cent.,	8	6
Potassium oxide from 4 to 5 per cent.,	12	12
Potassium oxide from 3 to 4 per cent.,	8	10
Potassium oxide below 3 per cent.,	3	7
Phosphoric acid from 1 to 2 per cent.,	34	30
Phosphoric acid above 2 per cent.,	none	3
Phosphoric acid below 1 per cent.,	3	12
Average per cent. of calcium oxide (lime),	29.39	30.16
Insoluble matter below 10 per cent.,	7	6
Insoluble matter from 10 to 15 per cent.,	12	18
Insoluble matter above 15 per cent.,	17	20

Table showing the Maximum, Minimum and Average Per Cents. of the Different Ingredients found in Wood Ashes for the Seasons of 1903 and 1904.

	MAXIMUM.		MINIMUM.		AVERAGE.	
	1903.	**1904.**	**1903.**	**1904.**	**1903.**	**1904.**
Moisture,	37.34	37.85	2.27	none	15.23	14.42
Potassium oxide,	8.15	11.04	1.68	.80	4.76	4.51
Phosphoric acid,	1.80	6.07	.46	.28	1.37	1.37
Calcium oxide,	35.75	42.86	22.33	19.73	29.39	30.16
Insoluble matter,	28.85	47.21	1.40	4.56	15.07	18.35

From the above tables it will be seen that the percentage of potassium oxide in the wood ashes received during the season is, on the average, somewhat less than for the previous season. The average of phosphoric acid is the same; while the average percentage of lime is somewhat higher than for 1903.

A study of these tables will emphasize the importance of buying this class of material on a statement of a guaranteed composition. We would urge all parties to ask for a positive guarantee of the amount of potassium oxide, phosphoric acid and calcium oxide (although our State law does not oblige the manufacturer to guarantee the latter element, it should be required when buying this class of fertilizers) said to be contained in this or similar classes of fertilizers. We would also advise all parties to patronize those dealers and importers who have complied with our State laws by securing a license for the sale of their article in Massachusetts. It is only in this way that protection by our State laws can be secured.

(*b*) *Lime Ashes.* — What has been said regarding wood ashes applies with equal force to lime ashes. They should always be bought on a statement of the guarantee of lime, potash and phosphoric acid which they contain, as they are more apt to vary widely in chemical composition than even wood ashes.

Table showing the Maximum, Minimum and Average Per Cents. of the Different Ingredients found in Lime Ashes for the Seasons of 1903 and 1904.

	MAXIMUM.		MINIMUM.		AVERAGE.	
	1903.	**1904.**	**1903.**	**1904.**	**1903.**	**1904.**
Moisture, ...	23.16	36.62	10.47	none	15.66	10.88
Potassium oxide, . .	3.32	2.46	.76	.06	1.86	1.54
Phosphoric acid, . .	1.66	1.48	.03	trace	.63	.74
Calcium oxide, . . .	55.44	55.24	32.42	21.92	41.15	42.93
Insoluble matter, . .	26.50	25.47	1.10	2.76	6.46	8.11

From the above comparison it will be seen that the lime ashes during the present season analyzed a little higher in lime and a little lower in potash than in 1903.

3. NOTES ON PHOSPHATIC SLAG AND EXPERIMENTS WITH NATIVE PHOSPHATES.

In one of our previous annual reports (thirteenth annual report, 1901, of Hatch Experiment Station of Massachusetts Agricultural College, pp. 68–70) we have discussed in detail the history and timely appearance of the basic slag phosphate in our general markets. In this article we pointed out the special modes of analysis that were in use in testing this material, also certain changes that have taken place in many localities in preparing the phosphatic slag by the addition of silica in a fusing process to change the free lime which is present in the slag to a silicate of lime, thus showing, it is claimed, a larger percentage of available phosphoric acid.

Samples of phosphatic slag have been collected in our general markets during the past year. This would indicate that this class of material was claiming the attention of agriculturists more than in the past. The extensive introduction of new methods of iron manufacture has largely increased the supply of phosphatic slag. Results of field experiments have shown the superior value of this material and demonstrated its fitness as a manurial matter. In view of the above facts, we have again taken this subject up for discussion.

The following table gives the results of analysis of samples of phosphatic slag made at the laboratory during 1904, in comparison with the average of analyses of slags made at the station in years past. Sample I. was imported from England in 1904; Sample II. was collected in our general markets during the spring of 1904; Sample III. was the average of all previous analyses made at the station.

Analysis of Samples (Per Cent.).

	Sample I.	Sample II.	Sample III.
Moisture,	.15	none	.99
Total phosphoric acid,	18.61	20.52	20.61
Available phosphoric acid,	–	4.96	4.05
Insoluble phosphoric acid,	–	15.56	19.02
Calcium oxide,	50.58	46.78	50.32
Insoluble matter,	–	18.78	6.59

From the results of the above compilation of analyses it will be seen that the present phosphatic slag does not differ materially from that of the past. The two samples analyzed during the year showed the presence of free lime, which fact was recognized and the mode of analysis was so modified as to counteract the action of the free lime before subjecting the samples to the usual treatment with neutral citrate of ammonia for the dermination of the available phosphoric acid.

The attempt to imitate the phosphatic slag, by fusing apatite with soda ash at 600° to 800° C., was mentioned in our previous annual report. Observations have been extended along this line during recent years by fusing natural phosphates with carnallite and kieserite for ten to fifteen minutes, at a temperature of 650° to 800° C. This treatment gave a compound analyzing: —

	Per Cent.
Total phosphoric acid,	20.71
Phosphoric acid soluble in 2 per cent. citric acid solution,	15.23
Calcium oxide,	9.92
Magnesium oxide,	10.20
Potassium oxide,	6.85
Chlorine,	16.47

It was reported that the effect of this fertilizer on oats and peas was somewhat superior to phosphatic slag, as regards the yield of grain.

Another substitute for slag phosphate is described by Prof. P. Wagner: 100 parts of coarsely crushed phosphorite is fused with 70 parts of acid sodium sulfate; 20 parts of calcium carbonate, 22 parts of sand and 6 to 7 parts of coal; this gave a product testing 15.7 per cent. phosphoric acid, practically all of which was soluble in citric acid solution. Pot experiments were conducted on oats, grown on loam soil, by the aid of this mixture, alongside of similar experiments conducted with a superphosphate testing 17.7 per cent. water-soluble phosphoric acid and 18.9 per cent. total phosphoric acid and phosphatic slag, testing 18 per cent. citric acid soluble phosphoric and 19.9 per cent. total phosphoric acid. The fused mixture gave as quick-acting and effective results as the superphosphate, and also gave results superior to the basic slag phosphate.

During the winter of 1902 Mr. H. D. Haskins of this department made some interesting experiments in fusing Canadian apatite with a mixture of sodium and potassium carbonates. The apatite was a high-grade material, testing

31.22 per cent. phosphoric acid and 51.74 per cent. calcium oxide. His experiments were conducted as follows: 1 part of the apatite was fused with 4 parts of a mixture composed of 23 parts of sodium carbonate and 39 parts of potassium carbonate. The resulting mass was extracted with water, and showed a test of 3.68 per cent. water-soluble phosphoric acid. The residue, upon treatment with neutral citrate of ammonia, showed a test of 26.78 per cent. of reverted phosphoric acid, leaving only .76 per cent. of phosphoric acid in an insoluble form. In another experiment 1 part of the apatite was fused with 1.15 parts of the same fusing mixture, this amount of sodium and potassium carbonate being theoretically necessary to convert all of the phosphoric acid into phosphates of soda and potash. The resulting mass showed 2.56 per cent. of water-soluble phosphoric acid, 15.96 per cent. of reverted phosphoric acid and 12.70 per cent. of insoluble phosphoric acid. Mr. Haskins also made experiments to ascertain to what extent the phosphoric acid in apatite would become available if boiled with a solution of sodium and potassium carbonate. Several strengths of solution were used, but only traces of phosphoric acid were dissolved, the residue in no case showing over 1.98 per cent. available phosphoric acid. From the above observations it will appear that great fields are opened for a more extensive use of our natural phosphates when introduced in a suitable form by some fusing process.

In conclusion, we must say that the consumption of commercial fertilizers is ever on the increase, and it is a great satisfaction to feel that apparently the increased consumption of fertilizers is more than off-set by the prospective increase in natural supplies. The increased production of sulfate of ammonia from improved methods in the manufacture of coke from bituminous coal, the recent discoveries of new potash deposits in Saxony, Ger., as well as the recent reported discovery of nitrate of soda beds along the Pacific coast in the United States, all furnish pleasant reflections for the future of American agriculture.

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD, H. T. FERNALD.

A number of different lines of investigation have been begun or continued during the year 1904, in addition to what may be termed the routine work of the division.

Experiments to determine the best treatment for the San José scale, begun at this station in 1902, have been concluded, at least for the present, as they have resulted in so thoroughly freeing the college orchard from this pest as to leave no material for further experiment. It is true that the scale is not exterminated, but it is present in such small numbers that several years must elapse before the orchard will become so reinfested as to be of any value for experimental purposes. On the other hand, it is impossible under present conditions to attempt experimental work elsewhere, and therefore this line of research is at least temporarily suspended.

A number of private preparations claiming to be useful as insecticides have been tested during the year, with varying results; but none have thus far been found which appear to be of great value. Whether it is worth while to take the large amount of time necessary for these tests, when the results, if they should ever by any chance prove valuable, would practically only produce free advertising to those manufacturing them, is certainly questionable, particularly as scarcely any of these substances are made by residents of this State.

The codling moth is now treated by spraying during the egg-laying period of this insect. In the west there are several broods of this pest each year, but in Massachusetts there seems to be much uncertainty on this point. For two years observations have been conducted to determine the number of broods of this insect, and the proper times at which to spray the trees in order to obtain the best results. The difference in seasons is of course a factor in the determination of these points, and renders it necessary that the work be continued for a term of years before final results can be obtained.

The oyster-shell scale can easily be controlled by mild sprays if these are applied at the right times, but two years ago no one in Massachusetts seemed to know just that time. In States but a short distance south this pest has two broods, and it has been doubtful whether there were not two here also. In order to determine these questions, careful observations have been made during the last two years, and must be continued for several more in order to obtain reliable results.

For nearly three months of the year all the spare time of the entomologists was devoted to the preparation of an exhibit for the Louisiana Purchase Exposition, taking time which could otherwise have been devoted to experimental work. The nature and scope of this exhibit has been presented elsewhere, and need not be given here.

During the colder months of the year experimental work is practically impossible, and this time is made use of in putting together the results of previous investigations, and drawing conclusions from them; in classifying and arranging the materials gathered and received during the summer; in solving the more complex problems connected with cases of injury difficult to reach and control by ordinary means; and in original investigations of various kinds.

The correspondence with residents of the State requires a large amount of time. In 1903 this was less than usual, the reasons for it being considered in the last report. This year it has resumed its normal quantity, about 1,500 inquiries having been received and answered by letter, or by sending printed information on the topics concerned.

Particular effort has been made to obtain samples of the injuries caused by insects, these being often markedly characteristic, and therefore of the greatest utility in a collection so constantly referred to.

The card catalogue has now been installed in a new case, capable of holding 90,000 cards, and is in constant use; in fact, it is probably the most useful single piece of apparatus in the possession of the division. Additional cards are constantly being added as new literature is published.

INSECTS OF THE YEAR.

The unusually cold weather during the winter of 1903–04, together with a few sudden and marked fluctuations of the temperature, was not without its effect upon insect life, as was shown last summer, though perhaps less than might have been expected.

The San José scale was destroyed in large numbers by the winter-killing of trees, and to some extent on those which survived the winter. This demonstrates that this insect is not entirely hardy during severe winters in this latitude. Unfortunately, enough succeeded in living to produce many young during the summer, so that this insect is now somewhat more abundant than it was a year ago. It is generally distributed over the State east of the western slopes of the Connecticut valley, but seems not to have penetrated the Berkshire hills to any great extent. Spraying with the lime-sulphur mixture for this pest has been made use of by many fruit growers and others, and has proved to be an excellent method for its control.

Plant lice and root maggots have been fairly abundant this year, due perhaps to their great increase during 1903 enabling them to have so many descendants that a larger number than usual succeeded in passing the winter.

The white fly (*Aleyrodes*) in greenhouses has apparently spread in all directions, complaints of the destruction it has caused having been received from all parts of the State.

The red spider (*Tetranychus*, spp.) has also been very abundant, both in greenhouses and outside, where a characteristic brownish tinge on the leaves of affected plants has often been very noticeable.

The usual amount of correspondence about the treatment for ants in houses and on lawns, about cut-worms, wire worms, the oyster-shell and scurfy scales and the various soft scales, indicates that these pests have been as abundant as ever, and that many people are still entirely ignorant of the appearance of their commonest insect foes.

The brown-tail moth has continued to spread over the State, and has been found in Lunenburg, Clinton and Whitman, by the State nursery inspectors. This indicates that the insect is spreading westward rapidly, and that it will be present in all parts of Massachusetts within a very few years. During the middle of July, while the moths were flying, it was noticeable that they were attracted to light, many being destroyed by flying into open arc lights on the streets, in some cases falling to the ground below the lights in such numbers as to form heaps of noticeable size.

It has usually been believed that the amount of feeding done by these insects in the fall was so slight that it could be ignored. This year, however, the caterpillars, after hatching and even after forming their tents, fed so much that where they were abundant all the foliage was skeletonized and turned brown. This was very noticeable in parts of Belmont, Arlington, Winchester and elsewhere. After the pear and apple, oaks seemed to be a favorite food for this insect, and the browning of the foliage in places was so great that newspapers called attention to "an extra brood" of this pest, and in some cases discovered that it was "a new and hitherto unknown insect" which was causing the injury.

The gypsy moth is now generally distributed over its original territory, and in one or two places has spread beyond it. In the districts where it is most abundant, the destruction it formerly caused when unchecked is again seen, and the result if no means of repression or control are taken can easily be imagined by any one who has visited these places. Local organizations in the infested districts are taking action to destroy this and the brown-tail moth, and are doing splendid work; but this should be supplemented by work on broader lines and with more power than local organizations possess, if lasting results are to be hoped for.

REPORT OF THE AGRICULTURISTS.

WM. P. BROOKS; ASSISTANTS, F. R. CHURCH, S. B. HASKELL.

The work of the agricultural department of the experiment station during the past year has in the main followed the general lines of investigation which have recently engaged attention. These for the most part are connected with questions affecting the selection and use of manures and fertilizers. To give results of value, such experiments require numerous repetitions, because of variation in product due to seasons and to conditions which we cannot fully control. In the averages of a series of years the influence of such variations is in a measure eliminated, and deductions based upon such averages will serve as a basis in farm practice.

The work of the past season has involved the care of over 220 plots in the open field, 150 closed plots and 278 pots in vegetation experiments.

Our grass garden, which includes 48 species and 7 varieties, most of them occupying 1 square rod of land, has been cared for as usual. One-half of the area in each species has been kept constantly lawn-mown, with a view to studying the probable effects of grazing; and a considerable number of species which had become mixed have been renewed, after paring and burning the old turf for the destruction of seeds and roots of weeds and other grasses.

Numerous experiments with alfalfa, both on our own grounds and on the grounds of selected farmers, are in progress. The results of this work are to be given in a bulletin. It suffices for the present to say that we have nowhere attained results so satisfactory that the extensive sowing of this crop can be advised; it must still be regarded as in the experimental stage.

A few cultures of nitrogen-assimilating bacteria, sent out by the Department of Agriculture for use with legumes, have been tried, and, so far as can be judged, with disappointing results. A bulletin descriptive of this work and the results obtained will be prepared in due time.

We have increased the scope of our work with the new and promising varieties of timothy received from Prof. A. D. Hopkins of the West Virginia Experiment Station, five years ago. Several of these are distinct improvements upon the ordinary commercial timothy, and these are being increased as rapidly as possible, for the production of seed which will later be furnished to selected farmers for trial.

Variety work with wheat, oats and barley has engaged considerable attention. Seeds of 31 varieties which for a series of years had given remarkable crops in the Dominion of Canada were kindly donated for the purpose by Dr. William Saunders, director, Experimental Farms of Canada. It was hoped that these northern-grown grains might prove valuable, but the results were disappointing. Practically all varieties were affected by rust, and the yields of most were small. The range of variation in the crops obtained was as follows: for wheat, at the rate of from 6 to 15 bushels per acre; for barley, at the rate of from 6 to 26 bushels per acre; for oats, at the rate of from 40 to 55 bushels per acre. Among the varieties of oats, the Improved Ligowa, Bavarian, Thousand $ and Wide Awake gave the best yields, — all in excess of 50 bushels. These varieties would seem to be worthy of further attention.

The work with poultry has been along the same lines as last year, the relations of food combinations to egg production being the subject under investigation.

The statement of results obtained, presented in detail in this report, does not cover all the experiments in progress.

The principal subjects of inquiry discussed, and the more important results, are as follows: —

I. — To determine the relative value of barnyard manure, nitrate of soda, sulfate of ammonia and dried blood as sources of nitrogen. The crop of this year was potatoes, and, on the basis of yield, the rank of the nitrogen-furnishing materials is as follows: barnyard manure, nitrate of soda, dried blood, sulfate of ammonia. The nitrate ranks relatively lower this year than in any previous year of the experiment except last. On the basis of increases in all the crops grown since the experiment began, as compared with the no-nitrogen plots, the materials rank as follows: nitrate of soda, 100; barnyard manure, 83.6; dried blood, 66.9; sulfate of ammonia, 56.9. In this experiment we are also testing the stubble value to succeeding crops of legumes on the no-nitrogen plots. The results of this year indicate the soy bean crop stubble to have been of little value.

II. — To determine the relative value of muriate, as compared with high-grade sulfate of potash, for field crops. The results of this year indicate the sulfate to be considerably superior to the muriate both for rhubarb and for cabbages.

III. — To determine the relative value of different potash salts for field crops. The salts under comparison are high-grade sulfate, low-grade sulfate, kainit, muriate, nitrate, carbonate and silicate. The crops of this year were cabbages, field corn and ensilage corn. The most striking results of the comparison are the relatively very low yield of the silicate of potash and the relatively high yields obtained on the nitrate and the carbonate.

IV. — To determine the relative value of phosphates used in quantities furnishing equal phosphoric acid to each plot. The crop of this year was corn. The most striking result was the very inferior yield produced on the plot where Florida soft phosphate is used. This result, in exact agreement with results with different crops in earlier years, indicates a very low degree of availability for this phosphate.

V. — *A*. Soil test with corn. The crop of this year, the sixteenth during which the experiment has continued, was excellent on all plots to which potash has been annually applied. Where muriate of potash alone has been continuously used, the yield was at the rate of about 47 bushels per acre. Where muriate of potash and dissolved boneblack have been continuously used, the yield was at the rate of 53 bushels per acre, which is the best crop produced on any combination of fertilizers, and actually exceeds the yield on the plot where manure has been annually applied at the rate of 5 cords per acre. The experiment strikingly shows the great importance of the liberal supply of potash in fertilizers for the corn crop. *B.* Soil test with grass and clover. The nitrate of soda, whether used alone or in combination, caused a large increase in the first crop. The use of potash without lime had little effect upon the crop. Where potash has been used continuously for fifteen years, with two heavy applications of lime (in 1899 and 1904), the effect on the proportion of clover and on total yield was very marked. The most profitable crop produced by any fertilizer combination was obtained upon the plot to which dissolved bone-black and muriate of potash have been continuously applied. On the limed portion of this plot the yield is at the rate of 6,100 pounds of hay. The annual cost of the fertilizers applied to this plot has been $7.50.

VI. — To determine the relative value in crop production of a fertilizer mixture rich in potash, as compared with one representing the average of the special corn fertilizers purchasable in our markets. The result of this year is substantially equal crops under the two systems of manuring, at a cost of rather over $5 per acre less for the combination of fertilizers richer in potash.

VII. — To determine the relative value in corn production of a moderate application of manure alone, as compared with a smaller application of manure used in combination with 160 pounds of high-grade sulfate of potash per acre. The result of this year was crops under the two systems equal in amount of stover, but an average at the rate of 5 bushels of grain per acre less on the combination of manure and potash than on the manure alone. The difference in crop is not sufficient to cover the excess in cost of the larger amount of manure alone, as compared with the lesser amount of manure and potash.

VIII. — To determine the economic result of using in rotation on grass lands, the first year, barnyard manure, 8,000 pounds per acre; the second year, wood ashes, 1 ton per acre; and the third year, bone meal, 600, and muriate of potash, 200, pounds per acre. The average yield of hay during the past season, all three systems of manuring being represented on a total area of about 9 acres, is at the rate of 8,050 pounds of hay per acre. The average for the twelve years during which the experiment has continued (1893 to 1904, inclusive) is 6,718 pounds.

IX. — To determine which is better economy, — to spread manure as hauled from the stable during the winter, or to place in a large heap to be spread in spring. This experiment was repeated in five pairs of plots. The winter application gave the better yield in three cases, the spring application in two; but the difference in the value of the crop where the spring application gave the larger yield was not sufficient to cover the difference in the cost of the two systems of handling the manure, which amounts to $4.80 per acre. The winter of 1903 and 1904 was exceptionally favorable to good results from application at that season, as conditions were such that there was no washing over the surface.

X. — To determine whether the application of nitrate of soda after the harvesting of the first crop will give a profitable increase in the rowen crop. The increases produced were considerable, but, possibly because of somewhat deficient rainfall, were not sufficient to make the application distinctly profitable.

XI. — The variety test of potatoes. Forty-nine varieties of potatoes were tested. The yield obtained from the different varieties ranged from 104 bushels of merchantable potatoes per acre for the Clinton to 319 bushels of merchantable potatoes per acre for Simmon's Model. Seven varieties gave a yield in excess of the rate of 260 bushels per acre, namely: Simmon's Model, Extra Early White Rose, Great Divide, Steuben, 1904, Mills' New Rose Beauty. These varieties are mentioned in the order of their productiveness.

XII. — Comparison of different foods and combinations of foods furnishing essential nutrients in different nutritive ratios for laying hens. The hens were supported, at a cost of about ⅙ of a cent per hen daily, on mixtures of food rich in corn, as compared with a cost of about ¼ of a cent per hen daily, on mixtures of food rich in wheat. The food cost per egg was lowest on the food mixtures containing a large proportion of corn. The combination of feeds including a considerable portion of rice and rice meal gave the most satisfactory egg yield of any combination tested, but the cost of rice is too great to make it an economical food for poultry.

I. — MANURES AND FERTILIZERS FURNISHING NITROGEN COMPARED. (FIELD A.)

The experiments in Field A have two principal objects in view: first, to compare the efficiency (as measured by crop production) of a few standard materials which may be used on the farm as sources of nitrogen; second, to determine to what extent the introduction of a legume will render the application of nitrogen to a succeeding crop of another family unnecessary. The field includes eleven plots of one-tenth acre each. A full description of the plan followed will be found in the twelfth annual report of the Hatch Experiment Station. The materials furnishing nitrogen under comparison are barnyard manure, nitrate of soda, sulfate of ammonia and dried blood. With few and unimportant exceptions, each plot has been manured in the same way since 1890. All the plots annually receive equal and liberal amounts of materials supplying phosphoric acid and potash. Three plots in the field have had no nitrogen applied to them since 1884; the materials under comparison on the other plots in the field are applied in such quantities as to furnish nitrogen at the rate of 45 pounds per acre to each. Barnyard manure is applied to one plot, nitrate of soda to two, sulfate of ammonia to three and dried blood to two plots. The potash applied to these plots is supplied in the form of muriate to six plots, namely, 1, 3, 6, 7, 8 and 9. It is supplied in the form of low-grade sulfate to four plots, namely, 2, 4, 5 and 10. The crops grown in this experiment previous to this year in the order of their succession have been: oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover, potatoes, soy beans, potatoes, soy beans.

The crop of this year was potatoes. The variety was the Green Mountain. The seed, which was of fine quality, was grown in northern Maine. The land was plowed on May

3; manure and fertilizers were applied on the 7th, and the potatoes, which had been soaked in formalin solution for prevention of scab, were planted on May 11. The crop was thoroughly cared for throughout the season, although there was some injury from bugs, apparently due to the fact that the Paris green used for the first spraying on June 27 was impure. The vines were sprayed three times with Bordeaux mixture and Paris green: respectively, July 3, 18 and 30. There was apparently little injury from blight. The leaves on the plot to which manure was applied retained their green color considerably longer than those on the other plots. On September 10 they were estimated to be still about one-half green, while the proportion still remaining green on other plots was in general estimated to be about one-tenth to one-eighth. By September 22 the tops were dead, and the potatoes were dug between that date and the 29th. The rates of yield on the several plots and the source of nitrogen on each are shown in the following table: —

Yield of Potatoes per Acre (Bushels).

Plots.	NITROGEN FERTILIZERS USED.	Merchantable.	Small.
0, . .	Barnyard manure, ...	236.67	41.67
1, . .	Nitrate of soda (muriate of potash), ...	190.33	36.00
2, . .	Nitrate of soda (sulfate of potash), ...	188.17	33.50
3, . .	Dried blood (muriate of potash), ...	141.33	36.00
4, . .	No nitrogen (sulfate of potash), ...	96.33	30.00
5, . .	Sulfate of ammonia (sulfate of potash), . . .	157.50	19.17
6, . .	Sulfate of ammonia (muriate of potash), . . .	162.50	13.33
7, . .	No nitrogen (muriate of potash), ...	104.33	11.50
8, . .	Sulfate of ammonia (muriate of potash), . . .	113.50	32.50
9, . .	No nitrogen (muriate of potash), ...	141.67	36.17
10, . .	Dried blood (sulfate of potash), ...	232.33	24.17

The yield on the different plots varies widely, that on the plot receiving manure being the best in the field, and standing relatively much higher as compared with the plots receiving their nitrogen in the form of a fertilizer than in any previous year. It is believed that this result must be in large measure a consequence of the fact that the application of barnyard manure tends to maintain the stock of humus in the soil, and so keeps it in a condition more favorable to productive capacity. Neither the soy bean nor the potato leaves a residue which contributes materially to the humus content of the soil, and no other crops have been grown during the past five years. Experiments in continuous potato culture without manures in the Cornell University Experiment Station have shown in a striking manner the dependence of this crop upon the presence of a suitable proportion of organic matter in the soil.[1] The common observation that potatoes thrive exceptionally well in virgin soils and upon sod land points in the same direction.

The superiority of the yield on Plot 10 also is striking. This, in the writer's opinion, is due to the fact that the potatoes on this plot were covered by hand, while those on the other plots were covered by the use of the plow. The potatoes on this plot came up much more quickly and more vigorously than those on the others, and showed decided superiority in growth from the start.

The average yields of this year on the several fertilizers are shown in the following table: —

FERTILIZERS USED.	Merchantable (Bushels).	Small (Bushels).
Average of the no-nitrogen plots (3), ...	114.11	25.89
Average of the nitrate of soda plots (2), ...	189.25	34.75
Average of the dried blood plots (2), ...	186.83	30.09
Average of the sulfate of ammonia plots (3), . . .	124.50	21.67

As the result of all experiments previous to this year, it is found that the materials furnishing nitrogen have produced crops in the following relative amounts: —

	Per Cent.
Nitrate of soda, ...	100.00
Barnyard manure, ...	94.00
Dried blood, ...	90.40
Sulfate of ammonia, ...	90.30
No nitrogen, ...	72.80

Similar averages for this year are as follows: —

	Per Cent.
Nitrate of soda, ...	100.00
Barnyard manure, ...	124.30
Dried blood, ...	96.80
Sulfate of ammonia, ...	65.30
No nitrogen, ...	62.50

As was the case last year, the nitrate of soda stands relatively lower than in experiments of previous years, although it still maintains its superiority as compared with the other fertilizers furnishing nitrogen. The barnyard manure produces a superior crop, not, it is believed, because of the superior availability of the nitrogen it contains, but, as has been suggested, because of the better physical condition of the soil produced by the humus it furnishes.

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[1] Bulletin No. 196, Cornell University Experiment Station, p. 52.

If we compare the different materials used as sources of nitrogen on the basis of increase in crop rather than on the basis of total product, they rank to date for the entire period of the experiment 1890 to 1904 as follows: —

Relative Increases in Yields (Average for the Fifteen Years).

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	83.60
Dried blood,	66.90
Sulfate of ammonia,	59.90

These figures make the superiority of nitrate of soda as a source of fertilizer nitrogen very apparent. In view of the fact that at current prices it furnishes a pound of nitrogen at a lower cost than almost any other material, the advisability of depending chiefly upon the nitrate as a means of supplying the important element nitrogen becomes strikingly evident.

Effect of a Legume upon the Following Crop.

It is pointed out, in introducing what will be said under this topic, that the object in this experiment is not to test the effect of producing a legume which is plowed under, but simply the improvement, if any, derived from the roots and stubble the legume leaves behind when harvested. The results thus far indicate little improvement in the condition of the soil following the culture of the soy bean, with the exception of those obtained with the potato crop following soy beans in 1902. The introduction of the clover crop, on the other hand, was followed by marked improvement; and it would now appear possible that the good results with the potato crop in 1902 may have been in part at least a consequence of the unexhausted residue of the clover stubble and roots turned under in the spring of 1900. The following table, with the curve below it, makes the facts clear: —

Effect of Leguminous Crops upon the Following Crop (Pounds).

PLOTS (EACH ONE-TENTH ACRE).	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
	Oats.	Rye.	Soy Bean.	Oats.	Soy Bean.	Oats.	Soy Bean.	Oats.
Nitrogen plots, . .	343	484	1,965	598	620	494	1,740	445
No-nitrogen plots, .	290	421	1,443	540	452	370	1,143	197

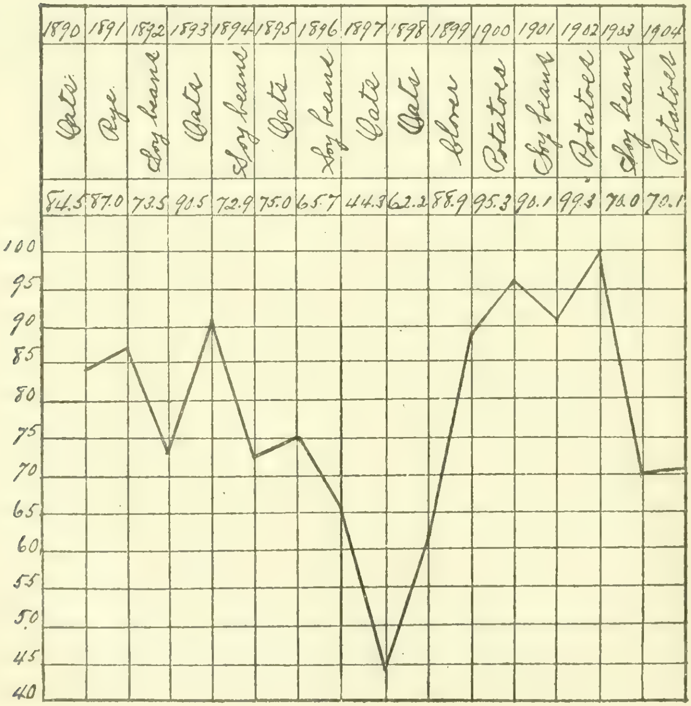
Effect of Leguminous Crops upon the Following Crop (Pounds) — Concluded.

PLOTS (EACH ONE-TENTH ACRE).	1898.	1899.	1900.	1901.	1902.	1903.	1904.
	Oats.	Clover.	Potatoes.	Soy Bean.	Potatoes.	Soy Bean.	Potatoes.
Nitrogen plots, . .	254	413	1,316	442.2[1]	1,053.6	2,726	1,199
No-nitrogen plots, .	158	367	1,254	398.3[1]	1,046.0	1,907	840

[1] Dry beans and straw.

Curve showing Relation of Average No-nitrogen to Average Nitrogen Plots, the Latter being considered in Each Year 100.

[Per cent. average no-nitrogen to average nitrogen.]



It will be noticed that the crops following soy beans have as a rule showed little improvement which can be attributed to that crop. So long as the soy bean was the legume grown, the crops on the no-nitrogen plots continued in general to decline, as compared with the crops obtained upon the nitrogen plots. This is indicated by the fairly uniform and comparatively rapid fall in the line indicating the relative production. The introduction of clover causes a marked rise in the line indicating production, and this continues during the first three seasons following the plowing of the clover sod. The effect of the soy beans upon the crop of potatoes grown in 1902 appears to have been distinctly beneficial; but, as was stated in the fifteenth annual report, the fact that the potato crop in 1902 suffered from blight undoubtedly favored the plots where the growth was relatively feeble. In commenting upon the results obtained in 1902, I said: —

> It may be that the relative standing of the no-nitrogen plots is higher than it would have been had the crop of potatoes grown to normal maturity. It will be remembered that blight and rot prevailed to a considerable extent, and these would naturally injure the potatoes with the ranker growth more than those where the growth was less luxuriant. It does not seem, therefore, that we are justified in concluding that the after-effect of the soy beans is as useful as the relation between the figures appears to indicate.

In view, then, of the doubt as to whether the true relative capacity for product was shown in 1902, and the further fact that all other years show a general agreement in not indicating a decided benefit following the introduction of the soy bean as a crop, we seem to be justified in the conclusion that the residual fertility left behind by the soy bean is comparatively unimportant.

II. — The Relative Value of Muriate and High-grade Sulfate of Potash. (Field B.)

The object in view in this experiment is to test the relative value of muriate and high-grade sulfate of potash when used continuously upon the same soil. The experiment was begun in 1892. The potash salts were used for the period from 1892 to 1899 inclusive, at the rate of 400 pounds per acre; since 1900 the rate of application has been 250 pounds per acre. Fine-ground bone at the rate of 600 pounds per acre has been yearly applied to all plots. The number of plots in the field at present is ten, five receiving muriate of potash, and alternating with the same number of plots which yearly receive sulfate of potash. Various crops have been grown in rotation, including potatoes, field corn, sweet corn, grasses, oats and vetch, barley and vetch, winter rye, clovers of various kinds, sugar beets, soy beans, and cabbages. Most of these crops have been grown during several years. With few exceptions, good yields have been obtained. Among the crops grown, the potatoes, clovers, cabbages and soy beans have usually done best on sulfate of potash. The yield of corn, grasses, oats, barley, vetches and sugar beets has been about equally good on the two salts, while the quality of the potatoes and sugar beets when grown on sulfate of potash has been distinctly better than on muriate of potash. Three years ago, two of the plots in this field were set to small fruits, asparagus and rhubarb, — on each plot one row each of raspberries, blackberries, asparagus and rhubarb. Aside from the crops just named, those of the past year have been cabbages on two plots and three varieties of clover, namely, Mammoth Red, Medium Red and Alsike, each on two plots. The clover was sown in the spring, and the product of the plots was considerably mixed with weeds; for this reason, the weights were not taken. There was no readily distinguishable difference in the growth of either the Medium or the Mammoth clovers that could be attributed to the difference in potash manuring. The Alsike clover upon the plot manured with sulfate of potash has made a distinctly better start than that on the muriate. Neither the asparagus, raspberries nor blackberries have yet become sufficiently established to give a full crop, and the results will not be reported in detail. The yield of asparagus was substantially equal on the two potash salts. The yield of raspberries on the muriate of potash was considerably greater than on the sulfate. Observation of the growth of the berry bushes and asparagus since they were set indicates that the rate of manuring which has been the practice on this field does not maintain the soil in sufficiently high fertility to produce satisfactory growth on either of the combinations of fertilizers employed. During the past season, therefore, we have used nitrate of soda at the rate of 200 pounds per acre, in connection with the customary amounts of bone meal and potash, on the plots occupied by these crops.

1. *Rhubarb* (*Sulfate v. Muriate of Potash*).

The rhubarb grown in this experiment is of the Monarch variety. The growth has been vigorous and healthy. The product of this year is shown in the following table: —

Muriate v. High-grade Sulfate of Potash (*Rhubarb*). — *Yields per Acre* (*Pounds*).

FERTILIZERS USED.	Stalks.	Leaves.
Muriate of potash,	8,421	11,957
Sulfate of potash,	8,559	14,286

The yield of stalks on the two plots is substantially equal, but the weight of the leaves accompanying the stalks produced on the sulfate of potash is materially greater than on the other potash salt. Whether this fact has any special significance is not at present known; but it is at least suggestive that on Field C, where, under conditions otherwise differing quite widely from those in Field B, the muriate is compared with the sulfate, a similar difference in weight of leaves as compared with stalks is found. It is, of course, evident that the results of this year do not throw any important light upon the question as to whether there is any important practical difference in the two potash salts for this crop.

2. *Cabbages* (*Sulfate v. Muriate of Potash*).

The variety of cabbages grown this year was Fottler's Brunswick Drumhead. The seed was planted in hills two feet apart and in rows three and one-half feet apart, on June 30. The plants were thinned first to two in a hill, and later, on August 16, to one. The summer and the autumn, especially the latter, averaged much below the normal temperature, and the cabbages were by no means matured on the approach of weather which compelled their harvesting. With a normal season there is no doubt that nearly all the plants would have produced merchantable heads. Under existing conditions a very large proportion of the heads were regarded as too soft to be included in that class. The yields per acre are shown in the following table: —

Muriate v. High-grade Sulfate of Potash (Cabbages). — Yields per Acre (Pounds).

FERTILIZERS USED.	Hard Heads.	Soft Heads.
Muriate of potash,	872	22,791
Sulfate of potash,	2,071	24,319

It will be seen that the product on the sulfate of potash is considerably superior to that on the muriate. The yield of hard heads is nearly two and one-half times as great, while the yield of soft heads also somewhat exceeds that on the muriate. As this result is in general agreement with that usually obtained heretofore with the cabbage crop, it tends to still further confirm the conclusion that it is best that the potash used for this crop be in the form of sulfate rather than muriate.

III. — COMPARISON OF DIFFERENT POTASH SALTS FOR FIELD CROPS. (FIELD G.)

Field G contains 40 plots, of about one-fortieth of an acre each. The experiments in progress have for their object the determination of the relative value for field crops of all the prominent potash salts when each is used continuously upon the same land throughout a long series of years. This experiment was begun in 1898. The plots are arranged in five series of eight each. In each series one plot has received no potash since the experiment began. The potash salts under trial are as follows: kainit, high-grade sulfate of potash, low-grade sulfate of potash, muriate of potash, nitrate of potash, carbonate of potash and silicate of potash. Each is always applied in such quantity as to furnish actual potash at the rate of 165 pounds per acre. All the plots in the field are yearly fertilized with materials supplying to each equal amounts of nitrogen and phosphoric acid. For nitrogen, nitrate of soda is applied at the rate of 250 pounds per acre, except on the plots where nitrate of potash is the source of the potash applied; here a suitable reduction in the quantity of nitrate of soda is made, on account of the nitrate nitrogen furnished by the potash salt. The principal source of phosphoric acid on these plots is acid phosphate, applied at the rate of 360 pounds per acre to all. Tankage at the rate of 270 pounds per acre is applied to all plots as a source of less immediately available nitrogen and phosphoric acid. The crops grown in this experiment in the order of succession are as follows: 1898, Medium Green soy beans; 1899, Beauty of Hebron potatoes; 1900, Fottler's Brunswick cabbage, Medium Green soy beans, Black cow pea, Wonderful cow pea; 1901, Turkish Red wheat, Medium Red clover; Rural Thoroughbred, Leaming Field, Boston Market and Eureka corn; 1902, Medium Red clover; 1903, Medium Red clover.

During the past season the crops grown in the field were as follows: cabbages on sixteen plots, two series of eight each; Sibley's Pride of the North corn on sixteen plots, two series; and Leaming Field corn for ensilage on eight plots. The season was unfavorable to full maturity for the cabbage crop, for reasons which have been alluded to in discussing results on fields B and C. For the same reasons, and also because of the excessive rains at the season of planting, the season was highly unfavorable to the corn crop. Defective germination, owing to the excessive rains, produced an uneven stand of plants in the areas devoted to corn. For the reasons indicated, it does not seem worth while to publish the results in full detail, and averages only will be given. These for the cabbages are as follows: —

Cabbages. — Average Rates of Yield per Acre (Pounds).

POTASH SALT.	Hard Heads.	Soft Heads.
No potash (plots 1, 9), ...	10,850	22,850
Kainit (plots 2, 10), ...	11,100	26,150
High-grade sulfate (plots 3, 11), ...	10,600	25,500
Low-grade sulfate (plots 4, 12), ...	12,100	27,400
Muriate of potash (plots 5, 13), ...	11,900	26,600
Nitrate of potash (plots 6, 14), ...	14,800	23,100
Carbonate of potash (plots 7, 15), ...	16,500	23,400
Silicate of potash (plots 8, 16), ...	10,650	25,050

The most striking points brought out by these figures are: first, the high-grade sulfate of potash fails to show the superiority in yield to muriate which has generally been shown; second, the nitrate and carbonate of potash have given yields very materially exceeding those obtained on any of the other potash salts; third, the yield on the silicate of potash is one of the poorest in the field.

Field Corn. — Average Yields per Acre.

Potash Salt.	Sound Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
No potash (plots 17, 25), ...	15.00	17.78	3,740
Kainit (plots 18, 26), ...	20.25	14.00	4,300
High-grade sulfate (plots 19, 27), ...	19.50	13.45	4,340
Low-grade sulfate (plots 20, 28), ...	17.75	14.34	4,200
Muriate of potash (plots 21, 29), ...	20.50	14.44	4,660
Nitrate of potash (plots 22, 30), ...	17.00	13.45	4,020
Carbonate of potash (plots 23, 31), ...	17.00	15.78	4,420
Silicate of potash (plots 24, 32), ...	13.75	18.56	4,160

The most striking point brought out by these averages is the poor results where the silicate is the potash salt employed. Aside from this, the results with corn seem to be in general accord with those which have been usually obtained, which indicate that the different potash salts appear to have substantially similar effects upon this crop.

Ensilage Corn. — Average Yield per Acre (Pounds).

Potash Salt.	Green Fodder.	Potash Salt.	Green Fodder.
No potash (plot 33), ...	28,800	Muriate (plot 37), ...	36,800
Kainit (plot 34), ...	38,800	Nitrate (plot 38), ...	32,800
High-grade sulfate (plot 35), .	34,600	Carbonate (plot 39), ...	30,000
Low-grade sulfate (plot 36), .	36,600	Silicate (plot 40), ...	22,400

In the case of the ensilage, as well as field corn, the silicate of potash gives a yield much inferior to that produced by the other potash salts. That the silicate, whether with cabbages, field or ensilage corn in each of the five series of plots where it is employed, gives yields inferior to those obtained with the other potash salts, and that the yield does not in some cases equal even the yield obtained from the no-potash plot, is a fact which it seems desirable to point out. Up to the present year the yields on silicate of potash with the different crops grown have not been markedly inferior to those obtained on other potash salts. It is impossible, in the light of our present knowledge of the conditions, to offer an explanation of the facts, although it is, of course, evident that the soil, which was originally in fair condition as regards its stock of available potash, has previous to this year been in condition to furnish a larger share of the potash needed by the crop than at present. With increasing exhaustion of natural stores of potash, the differences due to the several fertilizers used may naturally be expected to increase.

IV. — COMPARISON OF PHOSPHATES ON THE BASIS OF EQUAL APPLICATION OF PHOSPHORIC ACID.

The present is the eighth season of this experiment, which has for its object the determination as measured by crop production, of the relative availability of different materials which may be used as sources of phosphoric acid when used in such quantities as to furnish equal amounts of actual phosphoric acid to each plot, and in connection with materials which supply the other elements of plant food, especially the nitrogen and the potash, in abundance and in the same forms and in equal amounts on each of the plots. The field in which these experiments are carried on is divided into thirteen plots, of about one-eighth of an acre each. Three plots in the field, one at each end and one in the middle, have received no phosphoric acid since the experiment began. The phosphates which are employed on the other plots are as follows: apatite, South Carolina rock phosphate (fine ground), Florida soft phosphate, basic slag meal, Tennessee rock phosphate (fine ground), dissolved bone-black, raw bone meal, dissolved bone meal, steamed bone meal and acid phosphate. These phosphates are used in such quantities as to furnish actual phosphoric acid, at the rate of 96 pounds per acre. The nitrogen and potash fertilizers used supply nitrogen at the rate of 52 pounds and potash at the rate of 152 pounds per acre. With some of the crops grown (onions and cabbages) a supplementary application of quick-acting nitrogen fertilizers has been made to all plots alike. The crops which have been grown in the field during the progress of the experiment are as follows: corn, cabbages, corn, in 1900 two crops, — oats and Hungarian grass (both for hay), onions, onions, and cabbages. With the exception of the onions and cabbages, all the crops previously grown in the field have given good yields, even on the three no-phosphate plots. The soil of the different parts of the field was not even in fertility at the start. Plot 1 was somewhat more productive than any of the others, and in general the plots tended to decline in productiveness from 1 toward 13. The crop the past season was corn. The soil of the field inclines to be heavy, and the corn crop during the prevailing cool weather of the past season suffered from poor soil conditions and low temperature, especially on plots 8, 11, 12 and 13. Observation of the growth of the crop of the preceding year (cabbages), and study of the soil conditions throughout the preceding season, had led to the conclusion that the physical and chemical conditions of the soil in the field would be improved by a heavy application of lime. The field was plowed in the fall of 1903. Freshly slacked lime to the amount of 4,675 pounds (about 2,000 pounds per acre) was applied on May 10 and plowed in on May 15. The variety of corn grown was the Leaming Field. The seed was obtained of E. E. Chester & Son, Champaign, Ill., and was of excellent quality. The rainfall was so excessive, however, that there were a few blanks in some of the plots. The crop was cut on September 19 and immediately weighed and put into the silo. The rates of the yields on the several plots are shown in the following table: —

Plots.	FERTILIZERS USED.	Green Corn (Pounds per Acre).
1,	No phosphate,	41,000
2,	Apatite,	40,720
3,	South Carolina rock phosphate,	40,496
4,	Florida soft phosphate,	28,240
5,	Phosphatic slag,	36,440
6,	Tennessee phosphate,	32,120
7,	No phosphate,	32,344
8,	Dissolved bone-black,	30,080
9,	Raw bone,	45,800
10,	Dissolved bone meal,	41,840
11,	Steamed bone meal,	28,400
12,	Acid phosphate,	29,040
13,	No phosphate,	20,240

The point of principal significance in connection with the results appears to be the marked inferiority of the yield on the Florida soft phosphate. There was no difference in the physical conditions on this plot, as compared with those on either side, that can explain the wide difference in the amount of the product. The results of this year, then, additionally confirm the conclusions of previous years, — that this phosphate seems likely to give results which are distinctly disappointing, as compared with the claims of those interested in its production and sale. The low product on plots 8, 11 and 12 was undoubtedly in considerable measure due to the unfavorable conditions which have been referred to.

V. — Soil Tests.

In introducing what I have to say concerning soil tests, I cannot do better than to employ the language used in my last annual report, p. 244: —

> Two soil tests, both upon our own grounds and both in continuation of previous work upon the same fields, have been carried out during the past season. Fertilizers have been applied in accordance with the co-operative plan for soil tests, with one or two small exceptions. Lime and plaster have been applied to the plots calling for these fertilizers in double the usual soil test amounts. Each plot annually receives an application of the same kind or kinds of fertilizers. Such experiments are not adapted to securing the production of heavy crops. By study of the results, the effects of the different leading elements of plant food on the several crops can be determined with much accuracy.
>
> Every fertilizer used, whether applied by itself or in connection with one or both of the other fertilizer materials, is always applied in the same quantities. Both fertilizers and manure (where the latter is introduced for purposes of comparison) are always applied broadcast after plowing, and harrowed in. The kinds and the amounts per acre are as follows: —
>
> Nitrate of soda, 160 pounds, furnishing nitrogen.
> Dissolved bone-black, 320 pounds, furnishing phosphoric acid.
> Muriate of potash, 160 pounds, furnishing potash.
> Land plaster, 400 pounds.
> Lime, 800 pounds.
> Manure, 5 cords.

A. — *Soil Test with Corn* (*South Acre*).

This acre has been used in soil tests for sixteen years, beginning in 1889. The crops for successive years have been as follows: corn, corn, oats, grass and clover, grass and clover, corn (followed by mustard as a catch crop), rye, soy beans, white mustard, corn, corn, grass and clover, grass and clover, corn, corn, and corn. Since 1889 this field has, therefore, borne eight corn crops, and during this time it has been four years in grass. The present is the third successive corn crop, these three crops following grass, which occupied the field in 1901. Last season was one of the most unfavorable for corn within the memory of our oldest men. The crop was exceedingly small, even on the land which had annually received an application of manure at the rate of 5 cords per acre. With only one exception, previous to last year, the corn crop wherever potash has been applied to the soil in this field has always been good. In 1898 the crop even where potash and other fertilizers had been used was small. This suggested the probable necessity of an addition of lime. The application of lime at the rate of 1 ton to the acre restored the productiveness of all the plots to which muriate of potash had been continuously applied. The small crop of last year, in connection with observations on the condition of the soil, led to the conclusion that lime might once more prove useful; the entire field, therefore, was given a dressing of freshly slacked lime, at the rate of 1 ton per acre. The marked increase in the crop of this year wherever potash was used indicates the correctness of the opinion that lime was needed. The plot where potash was used alone last year gave a yield at the rate of about 15.5 bushels of corn per acre; this year the product is almost three times that amount. Last year the plot to which nitrate of soda and muriate of potash are annually applied gave a yield at the rate of 16.5 bushels per acre; this year the yield is 47.8 bushels. The plot receiving dissolved bone-black and muriate of potash, which last year gave a crop of a little less than 19 bushels, this year gave a crop of rather over 53 bushels. These facts make it strikingly evident that, in connection with fairly liberal amounts of muriate of potash, it is essential to use lime freely on many of our soils, if their productiveness is to be maintained. This field contains four plots, to which neither manure nor fertilizer of any kind has been applied during the sixteen years that the experiment has continued. These plots have now become very highly exhausted, producing crops which are practically valueless so far as the production of grain is concerned, although the nominal yield is at the rate of about 3.5 to 8 bushels per acre. The following table shows the fertilizers used on the several plots, the rate of yield, and the gain or loss per acre compared with the nothing plots: —

Corn. — South Acre Soil Test, 1904.

Plots.	FERTILIZERS USED.	YIELD PER ACRE.		GAIN OR LOSS PER ACRE, COMPARED WITH NOTHING PLOTS.	
		Corn (Bushels, 90 Pounds).	Stover (Pounds).	Corn (Bushels, 90 Pounds).	Stover (Pounds).
1, .	Nitrate of soda, ...	7.11	1,200	2.78	330
2, .	Dissolved bone-black, . .	3.89	960	—.44	90
3, .	Nothing, ...	4.33	870	–	–
4, .	Muriate of potash, . . .	46.89	3,760	42.86	2,933
5, .	Lime, ...	2.67	820	—1.07	—37
6, .	Nothing, ...	3.44	740	–	–
7, .	Manure, ...	50.00	4,000	46.56	3,260
8, .	Nitrate of soda and dissolved bone-black.	15.11	1,500	6.33	320
9, .	Nothing, ...	8.78	1,180	–	–
10, .	Nitrate of soda and muriate of potash.	47.67	3,560	39.71	2,440
11, .	Dissolved bone-black and muriate of potash.	53.11	3,940	45.96	2,880
12, .	Nothing, ...	6.33	1,000	–	–
13, .	Plaster, ...	7.44	1,100	1.11	100
14, .	Nitrate of soda, dissolved bone-black and muriate of potash.	47.78	3,700	41.45	2,600

It will at once be noticed that the potash is the element which determines the crop, almost to the exclusion of all others. Where potash has been used alone during sixteen years, the yield is almost as great as it is with potash and any of the other combinations. Nitrate of soda alone does very little good. Dissolved bone-black alone gives a crop less than the average of the nothing plots. The combination of nitrate of soda and dissolved bone-black gives a very inferior crop, but wherever potash is used the crop is good. Particular attention is called, further, to the fact that the continuous use of lime alone is not beneficial; on the contrary, the yield on the plot where lime has been continuously used is the poorest in the field. Plaster used alone and continuously gives a slightly better crop, but not much in excess of the nothing plots. It may perhaps be urged that the soil of this field must be of very exceptional character; that, otherwise, the so long-continued use of one fertilizer element could not produce the results obtained. To a certain extent this criticism may be justified, and I do not call particular attention to the marked effect of the potash for the purpose of urging upon our farmers exclusive dependence upon this fertilizer, but to make more emphatic the point that our farmers in general should insist that fertilizers designed for use for the corn crop should be richer in potash than is usually the case. The results obtained in previous years on this field indicate not so much that this soil is deficient in potash, — for some crops, such as grass, for example, do well on the plots to which no potash has been applied since the beginning of the experiment, — as that the corn crop depends in a marked degree upon a liberal supply of readily available potash.

B. — Soil Test with Mixed Grass and Clover (North Acre).

The acre used in the north soil test has been kept in this experiment fifteen years, beginning in 1890. The fertilizers have been used in the same combinations and in general in the same amounts on the several plots as in the south soil test, except that during the years when onions have been grown the fertilizers have been used in double the usual quantities. Each fertilizer or combination of fertilizers has been used continuously upon the same plot. In this experiment the plots were divided transversely in 1899, and lime was applied at the rate of 1 ton to the acre to one-half of each plot. The lime was applied after plowing, and harrowed in. During the past season the same halves of all the plots have once more been limed, and at practically the same rate as before; but this year, as the land was in grass, the lime was applied as a top-dressing on the grass in spring. The date of application was May 13. The crops grown in this field, in the order of succession, beginning in 1890, have been: potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and ruta-baga turnips, potatoes, onions for four years (1898 to 1901 inclusive), potatoes, grass and clover, and grass and clover. The field was sown to grass and clover after the harvesting of potatoes in the autumn of 1902 (September 15). The rate of seeding per acre was: timothy, 18 pounds; red-top, 8 pounds; red clover, 5 pounds; and alsike clover, 4 pounds. The clover winter-killed, and accordingly additional clover seed (15 pounds) was sown on April 4, 1903.

On account of the deficiency in rainfall from the middle of April to about the 10th of June, 1903, the yields last year on all plots were very small. The yields during the past season have been much larger. They are shown in the following table: —

Grass and Clover. — North Acre Soil Test, 1904.

Plots.	FERTILIZERS USED.	YIELD PER ACRE, HAY.		GAIN OR LOSS PER ACRE, COMPARED WITH NOTHING PLOTS.	
		Unlimed (Pounds).	Limed (Pounds).	Unlimed (Pounds).	Limed (Pounds).
1, .	Nothing, ...	1,060	800	–	–
2, .	Nitrate of soda, ...	1,960	1,600	1,067	880
3, .	Dissolved bone-black, . .	1,000	680	273	40
4, .	Nothing, ...	560	560	–	–
5, .	Muriate of potash, . . .	600	1,920	40	1,265
6, .	Nitrate of soda and dissolved bone-black.	2,120	2,320	1,560	1,570
7, .	Nitrate of soda and muriate of potash.	1,920	1,860	1,360	1,015
8, .	Nothing, ...	560	940	–	–
9, .	Dissolved bone-black and muriate of potash.	860	3,600	280	2,575
10, .	Nitrate of soda, dissolved bone-black and muriate of potash.	2,200	4,400	1,600	3,290
11, .	Plaster, ...	560	600	—60	—595
12, .	Nothing, ...	640	1,280	–	–

Grass and Clover. — North Acre Soil Test, 1904 — Concluded.

Plots.	Fertilizers used.	Yield per Acre, Rowen.		Gain or Loss per Acre, compared with Nothing Plots.	
		Unlimed (Pounds).	Limed (Pounds).	Unlimed (Pounds).	Limed (Pounds).
1, .	Nothing, ...	140	80	-	-
2, .	Nitrate of soda, ...	60	90	—30	7
3, .	Dissolved bone-black, . .	60	120	30	7
4, .	Nothing, ...	30	130	-	-
5, .	Muriate of potash, . . .	70	780	37	557
6, .	Nitrate of soda and dissolved bone-black.	210	810	175	495
7, .	Nitrate of soda and muriate of potash.	50	520	12	112
8, .	Nothing, ...	40	500	-	-
9, .	Dissolved bone-black and muriate of potash.	80	2,560	47	2,125
10, .	Nitrate of soda, dissolved bone-black and muriate of potash.	620	2,840	595	2,470
11, .	Plaster, ...	20	80	2	—225
12, .	Nothing, ...	10	240	-	-

The results of this year resemble those of last year in one particular, namely, the marked increase in the first crop which follows the application of nitrate of soda; but in one important particular the results this year differ from those of 1903 in a marked degree, namely, in the very large increase on the limed portion of those plots to which muriate of potash has been annually applied. In commenting upon the results of last year, I said: —

> Much evidence is afforded by a study of the relative proportions of the different species on the different plots and on the limed and unlimed portions of the several plots, that the soil in some parts of this field is once more becoming acid.

The principal ground on which this statement was based was the comparative absence of clover, even on the limed portion of such plots as had been supplied annually with potash. This relative absence of clover last year was doubtless in part due to the unfavorable climatic conditions; but the widely different results of this year indicate that the lime applied this season proved distinctly and largely beneficial.

It is desired to call particular attention to the yield both of hay and of rowen on the limed portion of Plot 9. This plot, it should be understood, has not received an application of anything furnishing nitrogen during the fifteen years that the experiment has continued ; and yet on the limed portion of this plot we this year have a yield of hay at the rate of 3,600 pounds and a yield of rowen at the rate of 2,560 pounds per acre, — a total of rather over 3 tons, at a fertilizer cost at the rate of $6.50 per acre. Allowing for an application of lime at the rate of a ton once in eight years, the annual cost of the materials applied to this plot amounts to about $7.50 per acre. The yields obtained at this very low cost indicate in a most striking manner the possibilities in the production of clover hay on soils naturally suited to clovers, without the use of the expensive nitrogen manures or fertilizers.

It is of especial interest to compare the yields of Plot 10 with those on Plot 9. Plot 10 has annually received nitrate of soda, in addition to the same amounts of dissolved bone-black and muriate of potash as are used on Plot 9. The result is a fair hay crop, even on the part of the plot where lime has not been used. Here, however, as on Plot 9, the yield is greatly increased by the application of lime, and we have a total in the two crops of the year at the rate of 7,240 pounds per acre. This exceeds the yield of the two crops on Plot 9 at the rate of a little more than a thousand pounds per acre. This increase is produced as the result of an application at the rate of 160 pounds of nitrate of soda. Such an application would cost about $4, and the increase is therefore produced at a moderate profit.

As in previous years, the relative proportion of the different species (red-top, timothy and clovers) on the several plots has been carefully studied. The most important points noted are as follows : first, the use of nitrate of soda increases the proportion of red-top ; second, potash increases the proportion of clover in a marked degree, and this influence is enormously increased on the limed portion of the plots.

It will be seen, by reference to the table showing how the fertilizers are applied, that Plot 6, which receives an application of nitrate of soda and dissolved bone-black annually, lies between two plots (5 and 7) each of which annually receives an application of potash. During the past season, and to some slight extent in previous seasons, it has been noticed that the growth of the crops on the edges of Plot 6, although it is separated from 5 and 7 by strips 3½ feet in width which have not received any fertilizer since the experiment began, shows plainly the influence of the potash applied to the neighboring plots, which has apparently diffused through the intervening 3½ feet strips, and is now beginning to affect the growth of the crops on Plot 6. During the past season there has been a little fringe of clover on each edge of Plot 6; this, however, has not been sufficient in amount to materially affect the yield on this plot, which, as will be seen, showed but little increase in the amount of rowen, which best measures the proportion of clover. The figures, however, for this plot are undoubtedly to some small degree misleading. The nitrate and the dissolved bone-black alone would produce little or no clover; they have, however, produced a fairly large crop of hay, about equally good on the unlimed and limed portions of the plot. This result is doubtless to be ascribed mainly to the effect of nitrate of soda in stimulating the growth of the grasses.

The relatively small increase on the limed portion of Plot 7, where nitrate of soda and muriate of potash are used together, appears to be due to the fact referred to in my last annual report, — that, where these two fertilizers are used together, soil effects very unfavorable to the growth of clover follow. It is believed that, to correct this unfavorable influence of these chemicals, lime must be used in very large amounts.

VI. — SPECIAL CORN FERTILIZER *v.* FERTILIZER RICHER IN POTASH.

It may be remembered that on this acre we are endeavoring to throw light upon the question as to the proper composition of fertilizers used alone for the corn crop. This experiment began in 1891. The crop from 1891 to 1896 inclusive was corn; in 1897 and 1898 the crop was mixed grass and clover; in 1899 and 1900 it was corn; in 1901 and 1902, grass and clover; in 1903 and 1904, corn. A statement of the results to date will be found in preceding annual reports. The object in view is to test the question as to whether the special corn fertilizers offered in our markets are of such composition as is best suited for the production of corn in rotation with mixed grass and clover. The field used in the experiment contains one acre, and is divided into four equal plots. Plots 1 and 3 have yearly received an application of mixed fertilizers, furnishing the same amount of nitrogen, phosphoric acid and potash as would be furnished by 1,800 pounds of fertilizer of the composition of the average of the special corn fertilizers analyzed at this station. This average has changed but little during recent years, and in 1899, since which date we have made no change in the kinds and amounts of fertilizers used, was as follows : —

	Per Cent.
Nitrogen,	2.37
Phosphoric acid,	10.00
Potash,	4.30

The various fertilizers offered in 1899 differed widely in composition. The extent of the variation is shown in the following table : —

	Per Cent.
Nitrogen,	1.5– 3.7
Phosphoric acid,	9.0–13.0
Potash,	1.5– 9.5

The fertilizers used on plots 2 and 4 are substantially the same in kind and amount as recommended in Bulletin No. 58 for corn on soils poor in organic matter. The essential difference in composition between the fertilizer mixtures under comparison is that that used on plots 2 and 4 is richer in potash and much poorer in phosphoric acid than the mixture representing the average market corn fertilizers. The fertilizers applied to the several plots are shown below : —

FERTILIZERS USED.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4 (Pounds Each).
Nitrate of soda,	30.0	50.0
Dried blood,	30.0	–
Dry ground fish,	37.5	50.0
Acid phosphate,	273.0	50.0
Muriate of potash,	37.5	62.5

The crop of the past two seasons has been corn, the crop of 1903 being the first to follow mixed grass and clover, which occupied the land in 1901 and 1902. The season of 1904, while too low in average temperature for the best growth of corn, was distinctly more favorable to the crop than 1903. The following tables show the yields on the several plots and the averages for the two systems of manuring: —

Yields of Corn, 1904.

PLOTS.	Good (Bushels).	Soft (Bushels).	Stover (Pounds).
Plot 1 (lesser potash), ...	59.25	7.78	10,640
Plot 2 (richer in potash), ...	57.50	9.33	9,208
Plot 3 (lesser potash), ...	57.75	7.79	8,280
Plot 4 (richer in potash), ...	55.25	13.56	9,660

Average Yields per Acre.

PLOTS.	Good (Bushels).	Soft (Bushels).	Stover (Pounds).
Plots 1 and 3 (lesser potash), ...	58.50	7.78	9,460
Plots 2 and 4 (richer in potash), ...	56.37	11.45	9,434

It will be seen that the yields under the two systems of fertilization were substantially equal, although the grain on plots 1 and 3 was better ripened than on the other plots. During the early part of the season the growth of the corn on plots 1 and 3 was materially better than on plots 2 and 4; the plants showed a better color and were of larger size. This difference showed itself very early in the season. On July 6, it was judged that the plants on plots 1 and 3 averaged one and one-half times the height of the plants on the other plots, and the difference in the growth on that date was judged to be considerably less than at an earlier period. As the season advanced, the corn on plots 2 and 4 steadily gained in condition and size, as compared with that on plots 1 and 3; and by the end of the season, as the harvest showed, the initial superiority on plots 1 and 3 had entirely disappeared. At present we are not in a position to state to what cause the superior growth on plots 1 and 3 early in the season was due; but it appears probable that the cause was the stimulative effect of the excess of phosphoric acid, which, as has been repeatedly shown, when used in liberal amounts exercises a marked effect in hastening maturity.

At present prices for fertilizer materials, the fertilizers used on plots 1 and 3 cost, laid down in Amherst, at the rate of $19.25 per acre; those used on plots 2 and 4 cost at the rate of $14.20 per acre. The fertilizer combination richer in potash, therefore, costs a little more than $5 per acre less than the combination representing average corn fertilizers. It is significant that at this lower cost we have a corn crop equal to that produced at the higher figure. Last year, when the corn crop on all plots was very poor, the yield on plots 1 and 3 was distinctly better than on plots 2 and 4; but, with that exception, the average results to date show corn crops substantially equal on the two fertilizer combinations, while whenever the land is put into mixed grass and clover, the fertilizer combination richer in potash gives crops materially larger and of better quality than the combination richer in phosphoric acid. The advantage to date, therefore, is most decidedly in favor of the fertilizer combination containing the more potash; and fertilizer manufacturers are urged to increase the proportion of this element in corn fertilizers, and farmers on their part should insist on such increase.

VII. — Manure Alone *v.* Manure and Potash.

These experiments, which have for their object to show the relative value as indicated by crop production of an average application of manure used alone, as compared with a smaller application of manure used in connection with a potash salt, were begun in 1890. The field used is level, and the soil of comparatively even quality. It is divided into four quarter-acre plots. The crop grown during the years 1890 to 1896, 1899 and 1900, 1903 and during the past season, has been corn. In 1897 and 1898, and again in 1901 and 1902, the crop was mixed grass and clover. Where manure is used alone, it is applied at the rate of 6 cords per acre. Where manure is used with potash, the rates of application are: manure, 4 cords; high-grade sulfate of potash, 160 pounds per acre. Manure alone is applied to plots 1 and 3; the lesser quantity of manure and high-grade sulfate of potash to plots 2 and 4. Estimating the manure alone as costing $5 per cord, applied to the land, the money difference in the cost of materials applied is at the rate of $5.30 per acre, the manure and potash costing that amount less than the larger quantity of manure alone. The tables show the rates of yield on the several plots, and the averages, under the two systems of manuring.

Yield of Corn, 1904.

PLOTS.	Corn (Bushels).	Stover (Pounds).
Plot 1 (manure alone),	68.25	5,840
Plot 2 (manure and potash),	66.25	5,280
Plot 3 (manure alone),	66.50	4,280
Plot 4 (manure and potash),	58.25	4,840

Average Yields per Acre.

PLOTS.	Corn (Bushels).	Stover (Pounds).
Plots 1 and 3 (manure alone),	67.37	5,060
Plots 2 and 4 (manure and potash),	62.25	5,060

The averages made show an equal amount of stover produced under the two systems of manuring, and slightly more than 5 bushels of corn per acre less on the combination of manure and potash than on the larger quantity of manure alone. This difference in yield is not sufficient to pay the added cost of the larger quantity of manure applied to plots 1 and 3; but, since manure is an article of home production on most farms where corn is grown, not much importance would be attached to this point by the average farmer. The corn crops produced under the two systems of manuring previous to this year have been substantially equal. The inferiority in yield this year is of consequence only on Plot 4; and it is suspected that accidental variation in conditions determined the smaller product on this plot, rather than the difference in the system of manuring. We know that the plants in the field, on account of imperfect germination due to the unfavorable weather which preceded and followed planting, were not as thick as is desirable. The fact, however, that the yield of stover on Plot 4 is greater than that on Plot 3, renders it exceedingly doubtful whether the cause of the relatively small yield of corn on Plot 4 was the greater proportion of unoccupied space.

VIII. — Experiment in Manuring Grass Land.

The report which is to be made concerning results in this experiment is best introduced by quoting from my sixteenth annual report: —

> In this experiment, which has continued since 1893, the purpose is to test a system of using manures in rotation for the production of grass. The area used in the experiment is about nine acres. It is divided into three approximately equal plots. The plan is to apply to each plot one year barnyard manure, the next year wood ashes, and the third year fine ground bone and muriate of potash. As we have three plots, the system of manuring has been so arranged that every year we have a plot illustrating the results of each of the applications under trial. The rates at which the several manures are employed are as follows: barnyard manure, 8 tons; wood ashes, 1 ton; ground bone, 600 pounds and muriate of potash, 200 pounds, per acre. The manure is always applied in the fall, ashes and the bone and potash in early spring.

The past season was exceptionally favorable for the production of a heavy yield of hay, but a relative deficiency in rainfall during the period occupied by the growth of the rowen crop was doubtless the principal reason for the falling off in the yield of rowen, as compared with that produced in the season of 1903. The yields of hay and rowen and the total yields for each system of manuring were at the following rates per acre: —

FERTILIZERS USED.	Hay (Pounds).	Rowen (Pounds).	Totals (Pounds).
Barnyard manure,	7,068	2,147	9,215
Bone and potash,	6,024	2,030	8,054
Wood ashes,	4,866	2,064	6,930

The average total yield of the entire area for this year is 8,050 pounds. The average for the entire period during which the experiment has continued (1893 to 1903 inclusive) is 6,597 pounds. The average to date is 6,718 pounds. The average yield when top-dressed with manure has been 7,026 pounds; when top-dressed with wood ashes, 6,304 pounds; when top-dressed with bone and potash, 6,686 pounds. The yields for the past year, it will be noticed, are considerably above the averages for the entire period.

Different Seed Mixtures compared.

In my last annual report[1] will be found a description of the variation in the seed mixtures used on different portions of two plots in this field (1 and 2). In one of these seed mixtures timothy is the most prominent species; in the other, meadow and tall Fescue are prominent; and these different mixtures may be spoken of respectively as the timothy mixture and the Fescue mixture. The timothy mixture is substantially the same as that in general use among farmers, including timothy, red-top, common red clover and alsike clover. The other mixture includes small quantities of all of these species, and in addition Kentucky blue-grass and the two Fescues named. In my last report the statement is made that it is believed that the Fescues will hold the ground more tenaciously than the timothy. The yields last year were materially greater on the portions of the plots occupied by the timothy mixture. The rates of yield on the two mixtures for the past season are as follows: —

	YIELD PER ACRE (POUNDS).	
	Hay.	Rowen.
Plot 1, Timothy mixture,	6,229	2,101
Plot 1, Fescue mixture,	5,769	2,121
Plot 2, Timothy mixture,	5,541	2,129
Plot 2, Fescue mixture,	5,896	2,597

The differences this year are materially less than last, and on Plot 2 the Fescue mixture has given the larger yield.

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[1] Sixteenth annual report, Hatch Experiment Station, pp. 145, 146.

The timothy has not yet been displaced by other species to any noticeable extent, but the poorer showing of the mixture in which it is prominent this year as compared with last possibly indicates that the belief that the Fescue mixture would ultimately prove the better of the two will be justified by the results obtained.

IX. — Experiment in the Application of Manure.

This experiment is designed to ascertain whether it is economically good policy to spread manure during the late fall and winter, and allow it to remain on the surface until spring before plowing under. This system in our experiment is compared with the plan of hauling manure to the field during the winter, and putting it into large heaps. To insure even quality of the manure used in the two systems, it is our practice to manure two plots at one time, putting the loads of manure as hauled to the field alternately upon the two, in the one case spreading, but in the other putting a sufficient number of loads to provide for the entire plot into one large heap. We are using in this experiment five large plots, each of which is subdivided into two subplots. For one of these subplots the manure is spread when hauled out, for the other it is put into a large heap. The area of these subplots is about one quarter of an acre, and to each the amount of manure applied is 11,096 pounds. The manure from well-fed milch cows is used upon eight subplots, and horse manure on two. The manure used in this experiment is applied at different dates during the winter, our practice being to allow the manure to accumulate in the pits from which it is taken until there is a sufficient quantity for at least two subplots. The condition of the soil at the time of application and the nature of the weather which follows must necessarily differ in the different experiments; and these differences, together with the difference in the dates of application above referred to, no doubt in a measure account for the variation in the results of the two systems noticed on the different plots.

The crop in this field last year was soy beans. After the beans were harvested, winter rye was sown as a cover crop.

The date of sowing was necessarily late, and the rye went into the winter very small. There was no injury, however, from winter-killing, and at the date of plowing last spring, May 14, this crop had made considerable growth. The crop of the past season was a mixed growth of Sibley's Pride of the North corn and Medium Green soy beans for ensilage. The corn, on account of seasonal peculiarities several times alluded to in this report, germinated somewhat imperfectly, and there was some damage due to pulling of the young plants by crows. The proportion of corn to beans, therefore, was somewhat lower than is desirable. The date of planting was June 13 and 14, the work having been impossible earlier, on account of the wet condition of the soil. Taking into consideration the condition of the soil at the time of planting and the relatively low temperature of the summer, the crop was fairly satisfactory; but it was undoubtedly unfavorably affected in places because of faulty soil conditions. It was judged that these conditions most seriously affected the several pairs of plots directly compared in the following table as follows: in Plot 1, on the south half; in Plot 2, on the north half; in Plot 3, on the south half; in Plot 4, on the south half; and in Plot 5, on the south half. These facts should be kept in mind in interpreting the results. The rates of yield per acre and the relative standing of the several plots are shown in the following table: —

Actual and Relative Yields of Green Forage. — Corn and Soy Beans.

PLOTS.	ACTUAL YIELDS (RATES PER ACRE, POUNDS).		RELATIVE YIELDS (PER CENT.).	
	North Half, Winter Application.	South Half, Spring Application.	North Half, Winter Application.	South Half, Spring Application.
Plot 1, ...	26,622	24,549	100	92.2
Plot 2, ...	20,548	22,062	100	107.4
Plot 3, ...	15,375	20,007	100	130.1
Plot 4, ...	22,167	20,595	100	92.9
Plot 5, ...	22,959	22,325	100	97.2

Attention is called to the fact that the differences this year, with one exception, are not very large, and that with the single exception alluded to it is the half-plot on which the soil conditions were least favorable which gives the smaller yield. The winter of 1903 and 1904 must be regarded as having been on the whole favorable to winter application. The ground, it is true, was deeply frozen before the coming of snow, but the winter was severely and continuously cold. There was a noticeable absence of winter rains and thaws, during which water washes in large quantities over the surface. In estimating the significance of the result, it must be kept in mind that it costs more to put manure first into a large heap and then in spring to take it from this heap and spread it, than it does to spread during the winter at the time the manure is hauled from the stable. The money difference in the cost of handling manure in the two ways, as shown by our experience, amounts to about $4.80 per acre. The difference in the value of the crops in favor of spring application is scarcely sufficient to cover this added cost, even on Plot 3, where such difference was greatest; and, although the unfavorable soil conditions above referred to doubtless lowered the product on that special plot where the manure was applied in the spring in three instances, plots 1, 4 and 5, it seems highly improbable that, even with equality of conditions, the gain from spring application on these plots would have given a degree of superiority sufficient to cover the added cost.

Previous reports have tended to show spring application to be advisable on this field, which has a considerable slope; and so I still believe it will in the long run prove to be. The exceptional character of the winter of 1903 and 1904 is a sufficient explanation of the difference in average results.

X. — Nitrate of Soda for Rowen.

This experiment is an effort to determine whether an application of nitrate of soda after the harvesting of the first crop will give an increase in rowen sufficient to cover the cost. The field where the experiment has been a number of times repeated is a mixed timothy and clover sod. It is divided into eight plots of like area, these plots being numbered 1 to 8 and each including about three-eighths of an acre. Nitrate of soda at the rate of 150 pounds per acre is applied to plots 2 and 4, while the application on Plot 6 is 200 pounds, and on Plot 8 250 pounds. To the remaining plots no nitrate is applied. The first crop of hay in this field was housed on July 14. The rate of yield was 6,314 pounds per acre. When this experiment has been tried in previous years, it has been found a matter of considerable difficulty to spread the relatively small amounts of nitrate of soda used evenly; and, as a means of obviating this difficulty, the nitrate used on each plot during the past season was mixed with basic slag meal. The amount of slag meal applied was 137½ pounds per plot, and the slag meal was applied to the plots receiving no nitrate as well as to the others, and on all in equal amounts. The mixture of slag and nitrate remained dry, and its even application was relatively easy. At the rates used, the nitrate and slag were mixed in proportions varying from about one nitrate to three slag to about one nitrate to two slag. Even with the higher proportions of nitrate to slag, the mixture remained dry and in convenient form for application. The rates of yields on the several plots are shown in the following table: —

Nitrate of Soda for Rowen. — Yields per Acre (Pounds).

[Basic slag meal at the rate of 137½ pounds per plot.]

Plots.	NITRATE USED (RATES PER ACRE).	Yield.
Plot 1, . . .	No nitrate, ...	716
Plot 2, . . .	Nitrate of soda, 150 pounds, ...	1,341
Plot 3, . . .	No nitrate, ...	990
Plot 4, . . .	Nitrate of soda, 150 pounds, ...	1,432
Plot 5, . . .	No nitrate, ...	853
Plot 6, . . .	Nitrate of soda, 200 pounds, ...	1,234
Plot 7, . . .	No nitrate, ...	1,021
Plot 8, . . .	Nitrate of soda, 250 pounds, ...	1,932

In the effort to determine whether the application of nitrate is profitable, the yield wherever it has been applied has been compared either with the yield of the nearest plot, or, in cases where it is possible, with the average yield of the two plots between which the plot under consideration lies to which no nitrate was applied. On this basis, the average increase due to application of 150 pounds of nitrate of soda was 499 pounds; the use of 200 pounds of nitrate of soda gave an apparent increase of 297 pounds; while the application of 250 pounds of nitrate of soda gave an apparent increase of 911 pounds. The weather during the period of growth of the rowen crop was too dry for the best results. At the rates of increase shown, the application would be hardly profitable.

XI. — Variety Test, Potatoes.

During the past season we have carried out the second year's trial of forty-nine different varieties of potatoes, including practically all of those of recent origin advertised in prominent seed catalogues up to the spring of 1903, as well as two or three old standard sorts for comparison. The seed used this year was grown from the original stock of each of the varieties on our own grounds in the season of 1903. The seed of all varieties was carefully preserved during the winter under precisely similar conditions. In preparation for planting, the tubers were treated with formalin for prevention of scab, in the customary manner. After removal from the formalin solution, they were spread in a thin layer in an airy room April 30, where they were allowed to lie until the 17th of May, when the tubers were cut into pieces of about two or three eyes each, and planted. The soil used in this experiment is a medium loam. It produced a corn crop in the season of 1903, and mixed grass and clover seeds were sown in the standing corn. Neither grass nor clover had made much growth when the field was plowed on May 3 in preparation for the potatoes. The field received an application of barnyard manure at the rate of 4½ cords per acre, and fertilizers at the following rates: —

	Pounds.
Nitrate of soda,	175
Dried blood,	225
Acid phosphate,	625
Dry ground fish,	400
High-grade sulfate of potash,	350

Both manure and fertilizers were spread evenly after plowing, and harrowed in. The varieties grown and the rate of yield of each are shown in the following table: —

Variety Test Potatoes. — Rates of Yield per Acre.

VARIETY.	Merchantable (Bushels).	Small (Bushels).
Admiral Foote,	208	25
Beauty of Hebron (home grown),	204	35
Beauty of Hebron (Maine seed),	167	21
Clinton,	104	10
Crine's Lightning,	210	7
Daughter of Early Rose,	221	8
Daybreak,	167	29
Early May,	161	33
Early Nancy,	225	27
Early Norwood,	215	40
Early Rose,	256	29
Ensign Bagley,	192	38
Eureka Extra Early,	196	38
Extra Early Pioneer,	204	42
Extra Early White Rose,	294	6
Gem of Aroostook,	248	42
Governor Yates,	259	29
Great Divide,	273	31
Hamilton's Early,	225	8
I. X. L.,	256	38
John Bull,	217	8
Junior Pride,	171	38
Kaiser Krone,	154	50
King of Michigan,	197	60
King of Ohio,	125	29
Market Prize,	256	8
Maxima,	263	31
Million Dollar,	225	13
Mills' New Rose Beauty,	263	15
Milwaukee,	165	25
New Early Wisconsin,	183	33
New Surprise,	204	29
1904,	263	27
Nome,	204	13
Nott's Peachblow,	192	14

Variety Test Potatoes. — Rates of Yield per Acre — Concluded.

Variety.	Merchantable (Bushels).	Small (Bushels).
Pat's Choice,	217	11
Peck's Early,	223	10
Prince Henry,	206	17
Red River Triumph,	208	14
Red River White Ohio,	156	31
Sensation,	248	14
Simmon's Model,	319	25
Snowflake, Jr.,	252	8
Steuben,	268	38
Sweet Home,	140	48
Van Ornam's Earliest,	197	17
Vornehm,	185	33
White Ohio,	146	27

The growth of practically all varieties was normal and healthy. The vines were sprayed twice with Bordeaux mixture for prevention of blight and rot. The treatment was successful, and the yield of most varieties was good. One variety, Simmon's Model, gave a yield exceeding 300 bushels per acre. The smallest yield is that given by the Clinton, — 104 bushels of merchantable tubers per acre. Six varieties, mentioned in the order of their productiveness, gave yields of merchantable tubers at rates between 260 and 300 bushels per acre, viz.: Extra Early White Rose, Great Divide, Steuben, Maxima, 1904, Mills' New Rose Beauty. The Beauty of Hebron, which in previous variety tests has given yields almost as large as any under trial, takes a lower rank as the result of the test of last season.

XII. — POULTRY EXPERIMENTS.

The poultry experiments of the past season have followed along precisely similar lines to those followed last year. We are making an effort to throw light on the question as to the proper selection of feeds for laying fowls.

1. In the experiment comparing wheat with corn, animal meal being the source of the animal food used, the following

results were obtained: for the first period, February 3 to May 17, the wheat ration produced eggs at the average rate of .4333 per hen day; the corn ration at the rate of .3837 per hen day; in other words, 100 hens would have laid per day on the wheat ration 43⅓ eggs, and on the corn ration practically 38⅓ eggs per day. For the second period, May 17 to September 30, the wheat ration produced an average of .1911 eggs per hen day, the corn ration .2067 eggs per hen day; or, in other words, 100 hens would have laid on the wheat ration about 19$\frac{1}{10}$ eggs and on the corn ration 20⅔ eggs per day. The average food cost per egg produced was for the wheat ration .611 cents, for the corn ration .505 cents for the first period; while for the second period the cost per egg on the wheat ration was 1.657 cents, and on the corn ration 1.315 cents. The gross cost of the food on the wheat ration varied from about .24 to .30 cents per day for each fowl, while on the corn ration the cost varied from about .17½ to about .26 cents per day. The yield of eggs during the second period was very small. The small average product is to be attributed largely to the fact that the period was continued beyond the date when the hens began to molt. The 20 hens on the wheat ration laid only 82 eggs during the last two months of the experiment, while those on the corn ration laid only 158 eggs during the same time.

2. In the experiment comparing wheat with corn, with milk albumin as the source of animal food and with corn oil added as a source of fat, the egg product was as follows: for the first period, February 3 to May 17, the wheat ration produced eggs at the average rate of .463 eggs per hen day, the corn ration .4324 eggs per hen day; or, in other words, 100 hens would have laid on the wheat ration practically 46⅓ eggs per day, and on the corn ration 43¼ eggs per day. For the second period the wheat ration gave an average of .3109 eggs per hen day, the corn ration .3017 eggs per hen day; or, in other words, respectively for the wheat ration an average of 31 eggs per 100 hens daily, and for the corn an average of 30⅙ eggs. The food cost of the eggs in this experiment was as follows: for the wheat ration during the

first period .5471 cents per egg, for the second period 1.3406 cents; for the corn ration the figures were for the first period .3932 cents per egg, and for the second .918 cents. The cost of feeding the hens was: for the wheat ration during the first period at the rate of .227 cents per day, for the second period, .39 cents; for the corn ration the cost of food for the first period was .155 cents per hen daily, for the second period .263 cents. The egg yield in this as in the other experiment is very low for the second period. The causes are similar to those which have been pointed out under 1.

3. In the experiment comparing wheat with rice, and with milk albumin as the source of animal food, the results have been as follows: for the first period the egg production was: for the wheat ration .3813 per hen day, for the rice ration .4077; or, in other words, from 100 hens daily respectively about 38⅛ and 40¾ eggs per day. For the second period the averages were on the wheat ration .2244 eggs per hen day, and on the rice ration .3018 eggs per hen day; or from 100 hens daily respectively nearly 22½ and a little more than 30⅙ eggs per day. The food cost of the eggs has been as follows: for the wheat ration for the first period .6976 cents, for the second period 1.59 cents; for the rice ration for the first period 1.1863 cents, for the second period 2.379 cents. The cost of keeping the hens has been as follows: for the wheat ration during the first period .2414 cents per hen daily, for the second period .34 cents; for the rice ration for the first period .4442 cents per hen daily, and for the second period .7003 cents.

The ration including rice this year as last has given one of the most satisfactory egg products obtained. The high cost of this food at the present time seems to preclude its becoming a question of much practical importance whether rice is well or ill suited as a food for egg production. We have introduced it in our experiments as a means of testing the question as to whether fat is an important constituent in the food for laying hens, rice being lower in fat than any other grain we can obtain. The large egg product where rice is prominent among the foods used seems to indicate that fat is less important than has been judged as the result of some of our earlier experiments. Among the various grains, cleaned rice, as put upon our markets, contains least fiber, and rice is known to be the most digestible of all the grains. It is perhaps these pecularities of this grain which account for its apparent good effect on the egg product.

The nutritive ratios in the food combinations used in the different experiments of the past year have been as follows : —

For the rations where wheat is compared with corn with animal meal as the source of animal food : for the wheat ration, 1 : 4.46 ; for the corn ration, 1 : 6.42.

For the experiment in which wheat is compared with corn, milk albumin being the source of animal food : for the wheat ration, 1 : 4.43 ; for the corn ration, 1 : 6.18.

In the experiment in which wheat and rice have been compared : for the wheat ration, 1 : 4.35 ; for the rice ration, 1 : 6.2.

Our experiments throw relatively little light upon the question as to the proper nutritive ratio in feeding for eggs. The factors affecting the egg yield must be numerous, and others than the question of the nutritive ratio in the foods given to the fowls must often determine the results. The fact that we have the most satisfactory egg yield obtained during the past year on the rice ration, with a nutritive ratio of 1 : 6.20, does not at least seem to support the opinion that the nutritive ratio in feeding for eggs should be narrow.

REPORT OF THE HORTICULTURISTS.

F. A. WAUGH; GEO. O. GREENE, ASSISTANT.

The work of this division has followed the plans outlined in the reports of 1902 and 1903. The following subjects are ready for discussion, and reports are made herewith: —

I. Report on plums.
II. Experiments in pruning peach trees.
III. Growing chrysanthemums for a retail trade.

Report on Plums.

The horticultural department has a fairly large collection of plums. A number of these are represented by several trees each, enough to determine their commercial quality. The plum crop of 1904 was unusually good; it was abundant in quantity, and generally of good quality. This was true of all classes of plums, practically every variety on the grounds bearing a normal crop. This furnished an excellent opportunity for making observations on the different varieties. The notes follow below. It has been thought best to omit any extended description of these varieties for the present. This form of report is justified by the fact that nearly all the varieties mentioned are old and well-known sorts. The notes this year are valuable chiefly in showing the behavior of these well-known varieties in this particular locality. The problem of local adaption of varieties is nowadays considered to be one of the most important in horticulture, and in no class of fruits or vegetables are these local adaptations more complicated than with plums. The varieties below are classified as nearly as possible into the more commonly accepted pomological groups.

DOMESTICAS.

Agen (*Prune d'Agen*). — Tree unhealthy and a poor grower, moderately productive, an irregular cropper; fruit very good, but not so bright nor large as in some localities.

Bradshaw. — This is one of the best plums of its class, and, indeed, one of the best market and home-use plums of any class on our grounds. We have about twenty young trees in bearing which gave a good crop in 1904. The tree is a strong somewhat upright grower, does not come early into bearing, but bears well after reaching an age of eight to ten years. The fruit buds do not seem to be tender here, as they are in some localities. The fruit is large, smooth, bright and of excellent quality.

Bryanstone. — Tree an irregular and slow grower, late and irregular in bearing; not reliable. Fruit small to medium in size; of good quality.

Clyman. — Represented only by a single specimen, which bears sparsely and does not seem to be of any value.

Dame Aubert (*Yellow Egg*, *Magnum Bonum*). — Tree rather upright in growth, fairly strong and hardy, but does not bear heavily. Fruit large and fine, but very subject to rot.

Damsons. — Several varieties of Damsons are included in our collection, among which the French Damson seems to be the best; this bears fairly well, but by no means as abundantly as in some sections.

Diamond. — A fairly strong, healthy tree, coming late into bearing, and yielding uncertain crops here.

Englebert (*Prince Englebert*). — Tree upright, strong and hardy; does not come early into bearing, but yields good crops after reaching ten years of age. Fruit of medium size and fair quality.

Fellenburg (*Italian Prune*). — Tree round-topped, bushy, with spreading irregular branches; does not bear until eight or ten years of age, and then not very heavily. Fruit of good quality. This variety does not rank so highly as a market plum as in western New York or Michigan.

Field. — Tree seems to be not very strong and healthy, but bears fairly well. Fruit of excellent quality. This is a promising, medium early plum.

Giant Prune. — Our trees are young and poor, and have borne only a few samples. The fruit is large and attractive. This variety is worthy of further test.

Gueii. — Tree rather a bushy grower; fairly productive. Fruit small, sour; not of the best quality.

Hand. — Tree a large, strong grower; shapely; notably unproductive. Fruit large, fine, showy. This variety is certainly not worth planting, the objection being its unproductive character.

Lincoln. — Tree not very strong or sound, and fruit not of very good quality. Not to be recommended, on the basis of our experience.

McLaughlin. — Tree unhealthy and a poor grower; not bearing very heavily. Fruit not so smooth and highly colored as in some sections, but still of very fine quality. In spite of its imperfections of tree, this variety is worth growing on account of its high quality; it would not be profitable in a market orchard.

Moore's Arctic. — Tree vigorous, upright, strong, hardy; productive, and coming fairly early into bearing. Fruit small; rather poor quality.

Peter's Yellow Gage. — Tree not very vigorous or hardy; a slow grower. Fruit small, and not very good for this variety.

Pond. — Tree large, strong grower; fairly productive. Fruit large and excellent, but very much subject to rot, and unprofitable on that account.

Quackenbos. — A very good, medium-sized tree, fairly productive. Fruit medium size; clean and fair quality for one of the small blue plums. This is probably the best of the so-called blue plums, with possibly the exception of Englebert.

Reine Claude. — Tree an irregular grower; not very vigorous, and only moderately productive. Fruit medium size and quality for this variety; considerably subject to rot. This takes the place of the old-fashioned Green Gage, being a larger, better and later variety. It is a very fine plum for canning, but could not be profitably grown for the market in this locality.

Saratoga. — Our single tree of this variety is small, and not very productive; unpromising.

Smith's Orleans. — Tree moderate size, somewhat irregular in growth; moderately productive. Fruit not so large or fine as it should be in this variety.

Tragedy. —We have only one tree of this variety, just coming into bearing; promising.

Victoria. — Tree moderately large; irregular in growth; moderately productive. Fruit of medium size and excellent quality; somewhat subject to rot.

Washington. — In almost all respects like Hand, which see.

JAPANESE VARIETIES.

Abundance. — Tree upright, early bearing; very much subject to disease. This is probably one of the poorest trees to be found amongst the Japanese plums. Fruit of good size and good quality; somewhat subject to rot; very apt to be eaten by birds. We would entirely discard this variety as a commercial plum, on the basis of our experience, and could not recommend it highly for planting for home use. This experience we are aware is different from that of some other plum growers in New England.

Burbank. — Tree vigorous, spreading, hardy; comes early into bearing, and is very productive. Fruit medium to large, good quality; less subject to rot than most plums. This is the most profitable and productive market plum on our grounds.

Chabot. — Tree upright, vase form; hardy, prolific. Fruit medium size, round red; fair quality. This is an excellent market plum, medium to late in season.

Georgeson. — Tree spreading, rather large growing, vigorous and hardy; fairly prolific. Fruit large, yellow; good quality. This is an excellent canning plum, and worth growing in this section, although it does not sell well in the markets on account of its yellow color.

Hale. — Tree upright, very vigorous grower; somewhat subject to winter-killing; coming rather late into bearing, never bearing abundantly. Fruit medium size, round; excellent quality. According to our experience, this variety is not worth planting in this section.

October Purple. — Tree vigorous, upright, and very strong grower; somewhat subject to winter-killing; coming late into bearing, but giving moderate crops after reaching an age of seven or eight years. Fruit medium size, rather dull color; good quality. The variety does not seem to be of any special value in this section.

Paragon. — Somewhat like Chabot, but of no special value.

Red June. — Tree spreading, vase form; vigorous and relatively hardy. The fruit buds on this variety are less hardy than on Burbank, however, sometimes being killed while Burbank survives. Trees bear early and abundantly. The fruit is one of the first to come into the market, and, though of second quality, usually brings a fair price. This is proved to be a profitable plum with us.

Satsuma. — Tree upright, spreading, moderate grower; not very hardy, bearing rather sparsely. Fruit usually small with us; of indifferent quality. Although this variety succeeds in other localities in the Connecticut valley, it is of no value here.

HYBRID VARIETIES.

Apple. — Tree very vigorous, sprawling grower; hardy, coming fairly early into bearing. Fruit medium large, round; dark red with red flesh. On our grounds this variety promises to take the place of Satsuma, to which it seems to be superior in most respects.

Compass Cherry. — An interesting hybrid curiosity, but of no value.

Doris (doubtfully placed among hybrids). — Tree spreading, vigorous, hardy. Fruit small, watery; of no value.

Duke. — Tree medium strong, upright; fruited this year for the first time; of doubtful promise.

Gold (of Stark Brothers). — Tree small, spreading, irregular in growth; hardy, bearing early, but never abundantly on our grounds. Fruit round oblate, medium size, yellow, watery; poor quality, ripening very unevenly; much subject to rot. This variety is of no value with us, and our trees have been mostly grafted to other sorts.

Juicy. — Tree strong and hardy. Fruit small, yellow; of no value.

Wickson. — Tree upright, strong grower; rather tardy in coming into bearing, and never bearing heavy crops; fruit buds tender, apt to be frozen. Fruit of medium size, variable in quality; ripening very irregularly. This variety is not to be recommended here.

NATIVE VARIETIES.

There are on the grounds several native varieties, mostly Americanas, Hortulanas and Chickasaws. Some of these do fairly well, but none of them have conspicuous merit as grown in this section.

Marketing Plums.

The very excellent crop of 1904 gave us an opportunity to study the manner in which plums can be sent to market. For the most part the crop from the department of horticulture of the Massachusetts Agricultural College was marketed in three-pound baskets, such as are used for grapes;

when these were shipped by freight or express, they were packed in crates holding approximately one bushel. This style of package proved generally satisfactory; it furnishes about the quantity of fruit desired by most purchasers.

In making local sales, especially of plums for canning purposes, a larger package was usually more satisfactory. The so-called Jersey peach basket, holding sixteen quarts (one-half bushel), is the cheapest and most convenient.

In some cases, where fancy plums are designed for the fruit stand trade, they may be put up in quart baskets, such as are used for strawberries. We find these also satisfactory.

This whole matter may be summarized by saying that most markets are not fastidious with respect to the form of package used for plums. Any small, neat basket or box will answer, if the fruit is of good quality and well packed.

Experiments in Pruning Peach Trees.

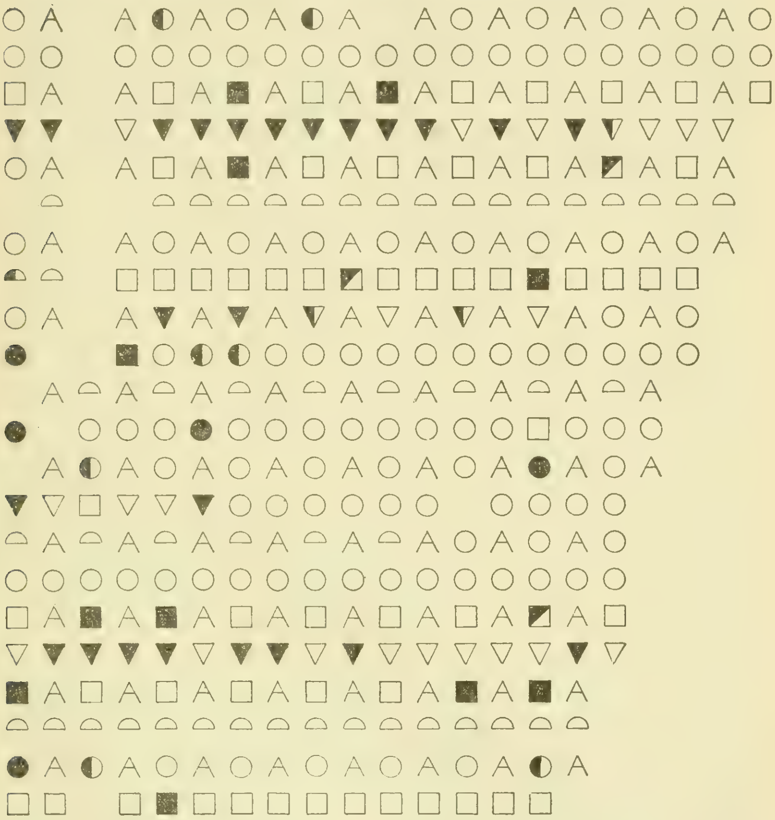
The department of horticulture has under way a series of experiments and special studies in pruning fruit trees. Reports on various phases of this work will be made from time to time as results are reached. At the present time we are able to make a report of progress in the experiments in pruning peach trees.

1. *The Results of No Pruning.*

One row of trees in the principal peach orchard has been left entirely without pruning from the first. This row runs crosswise of the variety rows, and therefore contains trees of all the varieties in the orchard, as follows: Oldmixon, Triumph, Mountain Rose, Elberta, Early Crawford, Late Crawford, Crosby. The trees are nine years old.

These trees, left unpruned for nine years, are plainly different from adjacent trees of the same varieties which have been pruned. Surprising as it may appear on first statement, they are more open-headed. They have generally assumed a vase form. The interior wood has died out, leaving the centres open, and at the same time leaving the lower part of the main branches bare. The fruiting wood is sparse, weak and high up in the trees. The trees are very much less thrifty and vigorous than the pruned trees of the same varieties. This lack of vigor is so marked that some of the weak trees succumbed more or less completely to the severe freezing of last winter.

The trees next the unpruned specimens have been headed back two or three times. They were all headed back moderately in the spring of 1902 and again in the spring of 1903, and some of them were headed back again in the spring of 1904. The trees so treated are thick-topped, with a good deal of weak, sappy growth on the inside, — a condition which is manifestly objectionable. On the other hand, the



Map of Experimental Orchard. — A shows apple trees 40 feet apart; the circles show peach trees unpruned; the half-circles show those slightly headed back; the squares indicate trees severely headed in; the triangles show trees cut back to stubs; the blackened figures represent trees which died in 1904.

annual growth has been much more vigorous, and the health of the trees has been much better. More and stronger fruit buds have been formed, but unfortunately the successive freezes of the last two winters have killed the buds, and made a comparison of fruit crops impossible. The main branches of the headed-back trees are shorter and stronger than those of the unpruned trees, and are obviously better able to support a large crop of fruit.

This experiment, which was begun by Prof. S. T. Maynard, and which has been continued through several years, has shown conclusively that the best form of peach tree cannot be secured and maintained without pruning.

2. *The Effect of Heading Back.*

Each spring, in the years 1902, 1903 and 1904, a number of trees in the college peach orchards were headed back. This shortening-in of the branches varied in amount: sometimes only one-third of the previous year's growth was cut away, sometimes one-half the year's growth was taken off, sometimes two-thirds was removed; in a few cases the trees were pruned clear back into two or three year old wood; in the majority of cases the heading-in amounted to about two-thirds of the previous year's growth. The cutting back in 1903 and in 1904 was more severe than it would have been had not the prospective fruit crop been wiped out by freezing.

In nearly all cases it was possible to compare trees thus headed in with other trees of the same varieties not so treated. The results were uniform and unequivocal. The trees headed back always made a more healthy and vigorous annual growth than the trees not so treated. In many cases the difference was remarkable, the growth of the pruned trees being from two to ten times as much as the unpruned trees. More and larger fruit buds formed on the pruned trees, and the shorter, stockier branches seemed better prepared to support a possible fruit crop. The foliage on the pruned trees was notably larger, more abundant and darker green. There was some tendency to the formation of weak shoots on the shaded interior branches.

The conclusion which we have reached from this experiment, continued through three years, is that the heading back of peach trees in early spring is good practice, and in all cases advisable. In this pruning from one-third to two-thirds of the wood of the previous year should be removed. In determining the exact amount to be cut away, the judgment of the fruit grower will be influenced largely by the number of living fruit buds in the one-year-old wood. If there is a crop in prospect, he will leave enough fruit buds to set the desired quantity of fruit. In years when, from one cause or another, there are no living fruit buds, he will take advantage of the circumstances to cut back with comparative severity. Only in extraordinary instances, however, will he remove all the previous year's wood, cutting back into two or three year old branches.

3. *Summer Pruning.*

It has been noted above that trees which were headed back in the early spring pruning showed a tendency toward the formation of many weak and useless shoots on the interior of the head. Experiments in summer pruning were begun with a view to the correction of this tendency, and also with a view to stopping the really inordinate extension of the main annual shoots of the current year. The two problems, however, were met in different ways.

The formation of weak sprouts on the interior of the tree is due chiefly to the exclusion of light. The external foliage of the tree top becomes so dense that the interior is shut off from the light and from much of the air. To improve the situation in this respect we have gone through the orchard once or twice between the middle of June and the middle of July, removing a considerable quantity of the new leafy shoots on the outside of the tree. A quantity of the outside shoots and foliage was thus removed sufficient to admit a reasonable amount of light to the inside of the tree top. The work was done with a pair of hand pruning shears, or, when the branches were soft, they were simply torn out with the bare hands. The latter method is preferable, because more expeditious.

In no case were the results of this treatment convincing. The formation of strong shoots with fruit buds on the interior branches was never visibly promoted. The outside branches which were allowed to remain seemed to profit somewhat by the removal of their crowding neighbors, and this was apparently the chief benefit derived from the work. On the whole, it does not seem to us that this practice is to be greatly recommended.

To correct the over-growth of outside branches, the plan was tried of cutting back the young growth. The tips were pinched or the shoots were pruned with hand pruning shears. Sometimes a foot or so of new growth was removed. The pruning was done at various seasons, usually some time in July.

In all cases this treatment was unsatisfactory. The stopping of the growing shoots is often — almost as a rule — followed by the pushing of side buds, and the shoots thus formed are nearly always too weak to set fruit buds, yet in putting out they ruin what might otherwise become strong, sound fruit buds.

4. *Pruning to renew Frozen Trees.*

As the spring of 1903 drew on, it was plain that more or less injury had been suffered by the trees in our peach orchards. In the spring of 1904 the damage was still more obvious and widespread. In both years some experiments were made to learn the best manner of handling a winter-injured tree.

The damage in the spring of 1903 proved to be small, and measures designed to have a corrective effect therefore showed meager results. All the trees came off about equally well, no matter how treated. Some were lightly headed in, some were severely headed in, while a few were cut back nearly to the main trunk, leaving only the stubs of the main branches. In every case not otherwise to be accounted for the tree recovered and made excellent growth.

In the spring of 1904 the trees were seriously weakened by freezing, and some were killed outright, so as to be beyond the reach of any remedial treatment. It should be said, however, that the damage proved to be less sweeping than was feared at the time the year's experiments were outlined. It was decided to lay off the orchard where this experiment was to be made into four blocks, to be given different kinds of treatment, as follows: (1) the first block was to be left entirely without pruning; (2) the second block was to be pruned in midsummer, after the trees had started; (3) the third block was to be cut back, from two-thirds to three-fourths of the previous year's growth being removed; (4) the fourth block was to be headed back near to the trunks, only the stubs of the main branches being left.

A certain percentage of these trees died during the year of 1904. The general result can be seen in the following table: —

Statistical Summary.

	Total Number pruned.	Living, Autumn of 1904.	Dead, Autumn of 1904.	Per Cent. Living.
Trees unpruned, ...	121	113	8	93
Moderately cut back, ...	48	47½	½	99
Severely cut back, ...	68	55	13	81
"Dehorned,"	46	24	22	52

It will be seen that the trees cut back to the trunks ("dehorned") suffered the worst; those severely cut back lost a larger percentage than those unpruned. A careful examination of the orchard itself makes it seem that the difference between blocks 2 and 3 in this respect is considerably exaggerated by the statistics. Some of the deaths in block 3 were apparently due to other causes, and should not be charged up against the pruning. Moreover, the growth made by the headed-in trees which lived was decidedly better than that made by the unpruned trees. The judgment of all those who saw the orchard and examined it carefully during the latter part of the summer of 1904 was that the trees moderately cut back showed the best growth and were in the best condition.

It at least seems clear that the trees seriously weakened by freezing should not be cut back close to the main trunks.

Growing Chrysanthemums for a Retail Trade.

By Francis Canning.

The work in the college greenhouses has to a certain extent been carried along on the lines and in many respects similar to that of a country florist's establishment, having a local trade. The many problems which present themselves under such conditions have been the subject of considerable experiment.

A florist's establishment in a country town is managed on a very different basis from that which obtains in growing cut flowers for the wholesale market, where two or three varieties of flowers are grown in quantity.

To meet the demands of a local trade requires the handling of a large variety of cut flowers and plants, not necessarily large in quantity, yet sufficient to meet the demand when any particular variety is in season.

One of the principal crops a florist grows under such conditions is the chrysanthemum, and it necessarily follows that he must be familiar with the earliest and latest flowering varieties, so as to prolong the season as far as possible. He must also ascertain which varieties are the best adapted for pot plants, also the colors which suit his trade.

The chrysanthemum having a short season, it follows that considerable forethought is necessary in the arrangement of space devoted to it; it frequently means the crowding of some other crops until that occupied by the chrysanthemum becomes available. To the uninitiated the transformation at the close of the chrysanthemum season, from beds filled with blooming plants to those occupied with other material, seems remarkable; yet the florist has long prearranged this matter in his mind. At this stage the saving of the necessary stock plants is done. In this connection a weeding out of undesirable varieties, or varieties that do not reach the standard in the grower's judgment, is accomplished. Various methods of saving the stock plants are practised; but we have found the use of boxes five or six inches in depth, with provision for drainage, to be a good method. It is better, however, not to mix several varieties in one box, for even though placed separately, the creeping stems will invade each other's territory, and result in mixing the varieties when the cuttings are taken. The boxes should be afforded a reasonably good place in a cool greenhouse, where the sun may reach them, so they do not have a soft, spindly growth, a condition exceedingly detrimental to future success.

Propagating commences in February, or much earlier when any special variety is to be considerably increased. After two batches of cuttings have been rooted, the boxes containing the stock plants may be thrown away, depending upon the newly propagated plants for future cuttings. From the earlier-rooted cuttings the varieties suitable for pot plants are selected, and are potted on as their needs demand. For the general stock for benching, or, in other words, for the cut flowers, the best time to propagate is from April 15 to May 1; thus suitable provision is made to have strong plants in two and one-half or three inch pots by the time the season arrives for planting. No specific date in this connection is observed, some florists commencing to plant in May and others late in July; but when the propagating has taken place at the previously mentioned date, the plants will be in good condition from the 15th to the end of June.

The question as to the advantages of solid beds or benches is of some interest. Our experience has been in favor of solid beds. We are, however, favored with a soil of a porous character, and gravelly subsoil, which for solid beds insures a good drainage, — a necessity for this crop. Wherever one may secure similar conditions, it would seem advisable to adopt this method, and thus avoid the expense of building benches and keeping them in repair.

The young plants are planted in rows eight inches apart each way, allowing two or three shoots to form, and thus secure the same number of blooms from each plant.

The soil used for benches and pot plants is a good, turfy loam, and is composted the previous fall or in the early spring of the same year. To three parts of soil is added one part of well-rotted manure, with bone meal to the amount of one quart to the barrowful of compost. To avoid fungous diseases, keeping the plants in good health by careful culture is the best preventative. For disposing of the ever-present aphis, or black fly, fumigation with tobacco has proved the surest and cheapest remedy. Throughout the year chrysanthemums should be subjected to a weekly fumigation, the prevention of insects being especially desirable in their successful management.

About forty varieties of chrysanthemums are grown in the college greenhouses, many of them represented by a few plants only, to ascertain their merits for such a trade as ours. This method of becoming acquainted with newer varieties should be adopted by all progressive florists. The fact remains, however, that many older varieties have not yet been superseded. Not infrequently the size of bloom has been the principal point in favor of the newer introductions, sacrificing in some instances their purity of color.

The following varieties have proved themselves well adapted for a local trade, being easily grown and naturally vigorous. In their order of flowering they are: white, — Polly Rose, Ivory, Alice Byron, Queen, Timothy Eaton, W. H. Chadwick, Merry Christmas; pink, — Glory of the Pacific, Pink Ivory, George Carpenter, Mrs. Perrin, Mrs. C. F. Berwind, Mrs. S. T. Murdock, Maud Dean; yellow, — Sinclair, Robert Halliday, Colonel Appleton, Major Bonaffon, W. H. Lincoln, W. H. Reiman; bronze, — Brutus, Sunrise, Petaluma; red, — Gettysburg, Malcome Lamond, Cullingfordii. The varieties that do well as pot plants are: Ivory, Alice Byron, Pink Ivory, Mrs. Perrin, Mrs. S. T. Murdock, Mrs. C. F. Berwind, Sinclair, Major Bonaffon, W. H. Lincoln, Brutus, Sunrise, Cullingfordii.

The singles and pompons should not be overlooked. They may be grown in pots with very little disbudding. They have a wide range of colors, and make salable pot plants; the white ones afford good material for designs, etc. Among the best may be mentioned Snowdrop, President, Julia Lagravere, Queen of England, Mizpah, Buttercup.

A great aid in the matter of testing the qualifications of varieties is the use of the "scale for judging" adopted by the Chrysanthemum Society of America. In scaling a variety a searching investigation is made, and many defects are apparent not ordinarily observed. In the work of the class in floriculture in the Massachusetts Agricultural College special emphasis has been placed upon judging chrysanthemums. Some practice will soon develop a rapid and correct estimate of the merits of varieties, and should prove valuable to the average florist.

The commercial scale is as follows: —

Color,	20
Form,	15
Fullness,	10
Stem,	15
Foliage,	15
Substance,	15
Size,	10
Total,	100

The score upon a number of varieties follows: —

	Major Bonaffon.	*The Queen.*
Color,	18	15
Form,	12	10
Fullness,	10	6
Stem,	15	15
Foliage,	15	10
Substance,	12	8
Size,	10	10
Total,	92	74

	Black Hawk.	*Colonel Appleton.*
Color,	20	20
Form,	7	12
Fullness,	10	8
Stem,	7	13
Foliage,	12	10
Substance,	8	12
Size,	8	10
Total,	72	85

These scores may vary from those awarded the same varieties by the Chrysanthemum Society of America. Our conditions may be accountable for the variation.

Some varieties present features especially desirable for a retail trade, — good keeping qualities, oddities in shape or color, etc. Those presenting desirable features, from two or three years' tests, follow: —

Baer, Mrs. G. F. — Known as Yellow Jerome Jones, and presents many of the fine characteristics of this fine variety.

Berwind, Mrs. C. F. — Dark pink, with silvery reverse; good keeper; a desirable kind.

Black Hawk. — Dark crimson; one of the handsomest of this color, and should be grown where there is any demand for this color.

Brutus. — Orange red; very dwarf in character; makes good pot plant and cut flowers; a desirable color, and satisfactory.

Byron, Miss Alice. — One of the best whites; makes a fine pot plant, and good for cut flowers.

Carpenter, George. — Medium early, dark pink flower; there is a demand for this variety when well grown.

Childs, G. H. — One of the best dark reds for cut flowers.

Dean, Maud. — One of the best pinks; large flower, good shape; fine for Thanksgiving trade.

Golden Trophy. — A desirable kind for pot plants.

Idavan. — Fine solid pink flower, shading to cream; a few are desirable.

Intensity. — Red; a good pot plant.

Jones, Mrs. Jerome. — One of the best whites.

Liberty. — A good late yellow; grown cool, will last till Christmas.

Merry Christmas. — A correspondingly late white variety.

Millbrook. — An odd salmon pink; a few pot plants may be serviceable.

Murdock, Mrs. S. T. — A desirable kind for cut flowers and plants; shell pink in color.

Mutual Friend. — A good white variety.

Petaluma. — An odd quilled-petalled variety; bronze or brown in color; good keeper.

Philadelphia. — Lemon yellow; globular flower; good for fancy trade.

Pitcher, Miss Georgiana. — A good old robust yellow variety, easily grown.

Reiman, W. H. — Yellow globular; late, good for Thanksgiving and later.

Rose, Polly. — An indispensable early variety.

Sunderbruch, H. L. — An early yellow; fine large flowers; good for pots.

Many other prominent varieties are being tested, a second year being desirable, to determine their value.

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PUBLIC DOCUMENT . . . . No. 33.

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HATCH EXPERIMENT STATION

OF THE

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APPROVED BY

THE STATE BOARD OF PUBLICATION.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

ORGANIZATION.

Committee on Experiment Department.

JAMES DRAPER, *Chairman.*
J. LEWIS ELLSWORTH.
WILLIAM H. BOWKER.
CHARLES H. PRESTON.
SAMUEL C. DAMON.
THE PRESIDENT OF THE COLLEGE, *ex officio.*

Station Staff.

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WILLIAM P. BROOKS, PH D.,	*Director and Agriculturist.*
GEORGE E. STONE, PH.D.,	*Botanist.*
JOSEPH B. LINDSEY, PH.D.,	*Chemist* (foods and feeding).
CHARLES H. FERNALD, PH.D.,	*Entomologist.*
FRANK A. WAUGH, M.S.,	*Horticulturist.*
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ROY F. GASKILL,	*Assistant in Foods and Feeding.*
WALTER B. HATCH, B.SC.,	*Assistant Horticulturist.*
CLIFTON H. CHADWICK,	*Observer.*

REPORT OF THE DIRECTOR.

WILLIAM P. BROOKS, DIRECTOR.

The work of the Hatch Experiment Station during the past year has progressed under favorable conditions. The only changes in the station staff have been a few affecting minor positions, which are elsewhere referred to. There has accordingly been no interruption in the lines of investigation which have been in progress.

Besides the monthly meteorological bulletins, during the past year four other bulletins have been issued: Nos. 103 and 104 on the subject of fertilizers and the results of analyses thereof; No. 105 on tomatoes under glass and methods of pruning tomatoes; and No. 106 on condimental stock and poultry foods.

The work of the section of our division of chemistry having to do with fertilizers shows that the conditions of the fertilizer trade in the State are substantially the same as during recent years. The manufacturers and dealers still offer an enormous number of different brands of so-called complete and special fertilizers in the markets. The number of samples analyzed during the past year is 511, representing 313 distinct brands. There can be no doubt that the business of manufacturing and selling fertilizers might easily be greatly simplified; that a great reduction in the number of brands offered, without loss in any direction, is possible; and that the result of such simplification and reduction in the number of brands would be that fertilizers sufficiently varied for every purpose could be furnished to the farmers at lower prices than those at present prevailing.

The fertilizer section of our division of chemistry has during the past year analyzed the usual number of samples of miscellaneous materials, wood ashes, lime ashes, soils, etc. Such samples as are sent in by the farmers are usually analyzed and the results reported without charge.

The bulletin on tomatoes under glass is an important contribution to knowledge on the best methods of handling this crop, which is coming to be one of much importance in this State. Bulletin No. 106, on condimental stock and poultry foods, presents analyses of a large number of foods coming under these classes. It discusses the utility of such foods, and their cost as compared with the more common food stuffs. It is clearly shown that their cost is in excess of what appears to be a perfectly fair estimate of their value. The bulletin presents a brief résumé of the results of experiments in the use of stock and poultry foods, which tends to show that the claims made for these foods are not justified by facts. The results of an experiment in the department of foods and feeding are presented and discussed, the conclusion being that the food under trial (Pratt's) did not appear to be superior in any way to a like mixture of corn meal and wheat middlings, while the cost was considerably greater.

In the division of foods and feeding, under Dr. J. B. Lindsey, a number of other important lines of investigation have been followed during the year. A somewhat full statement of the results in a number of these will be found in Dr. Lindsey's report, which is transmitted herewith. Among the more important results of these investigations are the following points : Bibby's dairy cake, a food which has been persistently urged upon the attention of our milk producers, has been carefully tested, but has been found to be less satisfactory from an economical point of view than some of the ordinary food stuffs.

Eureka corn has been carefully compared with Sibley's Pride of the North corn, from the standpoint both of production and of food value. It is found that, although the Eureka gives a much heavier yield, the excess in weight is made up almost exclusively of water. The food value of the product of an acre of Eureka corn is not equal to the food value of the much smaller acre product of Sibley's Pride of the North.

Wheat bran has been compared with corn silage, in connection in both cases with some of the more nitrogenous concentrates, as food for milch cows. The results indicate that silage is equally as satisfactory as the bran, and that by substitution of silage for the bran the necessary outlay for purchased foods in milk production can be greatly reduced.

This division has carried out an interesting investigation into the conditions prevailing in milk production in Amherst and neighboring towns. It is found that the conditions are often quite unsanitary; that bacteria are frequently exceedingly numerous in the milk, indicating improper methods of handling; and that in general there is urgent need of improvement. In the judgment of Dr. Lindsey, the results of this investigation indicate the desirability of the establishment of some regular system of inspecting dairies. It is believed that this is something which consumers in increasing numbers will be likely to insist upon in the near future.

In the horticultural division the only investigation sufficiently advanced to justify report is that undertaken, and in part reported upon in our last annual report, on methods of pruning peach trees injured by winter-killing. It will be remembered that four systems were under trial: no pruning, light pruning, moderate pruning, and severe pruning. Severe pruning consisted in removing nearly all the branches of the injured tree. The observations of another year lead to the conclusion that this system cannot be recommended. A more moderate pruning, consisting of the removal of from one-third to one-half of the growth of the previous year, seems to have given results which are on the whole most satisfactory; and such pruning is recommended in all cases when the wood has been injured by winter-killing. If only the fruit buds have been destroyed by the winter, it is recommended to prune back the previous season's growth severely, leaving only two or three buds.

In the entomological division, experiments are in progress with a view to determining the definite strength of hydrocyanic acid gas which can be used with safety on plants in greenhouses under varying conditions of growth.

In the report of the division of botany and vegetable pathology will be found a discussion of the general conditions as affecting plant diseases during the past year; references to the somewhat unusual attack of the potato rot fungus (*Phytopthora infestans*) on the tomato; and a discussion of the causes of sun scald and the browning of the foliage of conifers and other evergreens.

The report of the vegetable pathologist, Dr. George E. Stone, includes also a suggestive discussion on winter-killing as affecting trees and shrubs, as a result of the exceptionally cold winters 1902–03 and 1903–04.

The great importance of suitable aeration of the soil for perfect germination of certain seeds is brought out by another paper. The effects of sterilization of soils respectively rich and low in organic matter on germination and the growth of plants have been investigated. It has been found that, if the soil is rich in organic matter, sterilization is favorable both to germination and subsequent growth; but if the soil contains little organic matter, such treatment is unfavorable.

The influence of treating seeds in soil decoctions of varying strengths has been carefully studied, and it is shown that such decoctions from sterilized soil when highly diluted exercise a favorable effect on germination. The report of Dr. Stone includes also the presentation and discussion of results of various methods of seed selection. The conclusion is that, for seeds adapted to that method of handling, the use of sieves of suitable mesh as a means of separating the small and inferior seeds is strongly to be recommended. The use of other methods of separation in the case of seeds which cannot be successfully handled by sifting is urged, as being of much importance.

The work of the agricultural division during the past year has followed the usual lines, and is elsewhere briefly summarized.

Among the different bulletins and reports which have been issued by the station, the following are still in stock and can be furnished on demand: —

No. 3. Tuberculosis.

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.

No. 33. Glossary of fodder terms.

No. 41. On the use of tuberculin (translated from Dr. Bang).

No. 64. Analyses of concentrated feed stuffs.

No. 67. Grass thrips; treatment for thrips in greenhouses.

No. 75. Fertilizer analyses.

No. 76. The imported elm-leaf beetle.

No. 77. Fertilizer analyses.

No. 81. Fertilizer analyses; treatment of barnyard manure with absorbents; trade values of fertilizing ingredients.

No. 82. Orchard management; cover crops in orchards; pruning of orchards; report on fruits.

No. 83. Fertilizer analyses.

No. 84. Fertilizer analyses.

No. 87. Cucumbers under glass.

No. 89. Fertilizer analyses; ash analyses of plants; instructions regarding sampling of materials to be forwarded for analysis.

No. 90. Fertilizer analyses.

No. 92. Fertilizer analyses.

No. 95. Fertilizer analyses; notes on barnyard manure; trade values of fertilizing ingredients.

No. 96. Fungicides; insecticides; spraying calendar.

No. 97. A farm wood lot.

No. 98. Inspection of concentrates.

No. 99. Dried molasses beet pulp; the nutrition of horses.

No. 100. Fertilizer analyses; market values of fertilizing ingredients.

No. 102. Analyses of manurial substances and fertilizers; market values of fertilizing ingredients.

No. 103. Analyses of manurial substances; instructions regarding sampling of materials to be forwarded for analysis; instructions to manufactures, importers, agents and sellers of commercial fertilizers; discussion of trade values of fertilizing ingredients.

No. 104. Analyses of manurial substances and licensed fertilizers; market values of fertilizing ingredients.

No. 105. Tomatoes under glass; methods of pruning tomatoes.

No. 109. Condimental stock and poultry foods.
Special bulletin, — The coccid genera Chionaspis and Hemichionaspis.
Technical bulletin, No. 1, — Greenhouse Aleyrodes; strawberry Aleyrodes.
Technical bulletin, No. 2, — The graft union.
Index, 1888–95.
Annual reports, 1898, 1899, 1900, 1901, 1902, 1903, 1904, 1905, 1906.

Of most of the other bulletins a few copies remain, which can be supplied only to complete sets for libraries.

The co-operation and assistance of farmers, fruit growers and horticulturists, and all interested directly or indirectly in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

ANNUAL REPORT

Of George F. Mills, *Treasurer* of the Hatch Experiment Station of Massachusetts Agricultural College,

For the Year ending June 30, 1905.

Cash received from United States Treasurer,		$15,000 00
Cash paid for salaries,	$6,992 42	
for labor,	1,788 14	
for publications,	782 84	
for postage and stationery,	367 35	
for freight and express,	221 78	
for heat, light, water and power,	544 60	
for chemical supplies,	106 39	
for seeds, plants and sundry supplies,	410 48	
for fertilizers,	738 11	
for feeding stuffs,	379 78	
for library,	78 36	
for tools, implements and machinery,	398 37	
for furniture and fixtures,	162 26	
for scientific apparatus,	586 31	
for live stock,	127 05	
for travelling expenses,	158 46	
for contingent expenses,	25 00	
for building and repairs,	1,132 30	
		$15,000 00
Cash received from State Treasurer,	$13,625 00	
from fertilizer fees,	4,365 00	
from farm products,	1,512 95	
from miscellaneous sources,	3,463 70	
Balance June 30, 1904,	3,383 55	
		$26,350 20

Cash paid for salaries,	$13,678 34	
for labor,	2,337 59	
for publications,	651 50	
for postage and stationery,	308 52	
for freight and express,	136 62	
for heat, light, water and power,	1,021 32	
for chemical supplies,	615 56	
for seeds, plants and sundry supplies,	451 51	
for fertilizers,	7 39	
for feeding stuffs,	613 28	
for library,	92 08	
for tools, implements and machinery	17 33	
for furniture and fixtures,	174 11	
for scientific apparatus,	735 74	
for live stock,	172 00	
for travelling expenses,	1,400 79	
for buildings and repairs,	198 86	
Balance,	3,737 66	
		$26,350 20

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ended June 30, 1905; that I have found the same well kept and classified as above; that the receipts for the year from the Treasurer of the United States are shown to have been $15,000, and the corresponding disbursements $15,000; for all of which proper vouchers are on file and have been by me examined and found correct, thus leaving no balance of the $15,000; and that $3,737.66 are left of the State appropriation and of funds received from miscellaneous sources.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 7, 1905.

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

The attention of this division during the year has been largely confined to the work of making the usual observations of the various weather phenomena and a proper tabulation of these records, together with such computations as are found necessary for the purpose of comparison. The installation of some new apparatus has required some changes in the manner of tabulation, but the only effect on the results is to render them more accurate.

At the beginning of each month the usual bulletin of four pages has been issued, giving the more important daily records and monthly means, together with a summary of the results. The annual summary will be issued as a part of the December bulletin. In addition to issuing the bulletins, a considerable number of letters have been required to answer specific inquiries regarding rainfall, temperature and other features of the weather.

This station, being one of the voluntary observers' stations of the United States Weather Bureau, has furnished the section director at Boston with the usual monthly reports, and has also agreed to furnish the weekly snow reports during the winter. A phenological record has also been made, and a copy furnished the section director at his request.

The local forecast official at Boston has furnished this station with the local weather predictions daily except Sundays, and the proper signals have been displayed from the flagstaff on the tower. It was found necessary to shorten the flagstaff a few feet, but this has not resulted in making the signals less noticeable.

Owing to the unsatisfactory records made by some of the Draper self-recording instruments in the tower, it was decided to secure some of other make whose records would be more precise. Accordingly, a triple electric register for recording sunshine, rainfall and wind velocity was purchased from Julien P. Friez, and during the summer vacation the wiring was done to put it in working order. The sunshine recorder was mounted on top of the tower and connected by wires to the register in the tower. Two Edison primary batteries furnish the current required to operate the register at intervals of one minute while the sun is shining. A tipping-bucket rain gauge on the campus is connected to the register in the tower by more than a thousand feet of wire, and each one-hundredth of an inch of rainfall is registered. This furnishes a record of the rate of precipitation during a storm, as well as the total amount. The record is also checked by measurement in a standard rain gauge. A small anemometer of the Weather Bureau pattern was mounted on top of the tower in place of the Draper rain gauge, which was taken down, and each mile of wind travelled is recorded on the register below. As the drum on which all the above-mentioned records are made travels at a rate of nearly three miles per hour, the records are very distinct, and variations in rate of wind movement, as well as in the rainfall, are easily noted. A set of maximum and minimum thermometers of the Weather Bureau pattern was purchased during the year, to replace others that were greatly worn.

The assistant observer, Mr. C. H. Chadwick, was advanced to the position of observer in June, succeeding Mr. G. W. Patch.

REPORT OF THE AGRICULTURISTS.

WM. P. BROOKS; ASSISTANTS, F. R. CHURCH, S. B. HASKELL.

The work of the agricultural department for the past year has closely followed the lines of recent years. The leading object of our work is, by long-continued comparative experiments, to throw light upon some of the many problems connected with the use of manures and fertilizers. The results of a single year may be of value as a guide to practice, but it is important to know concerning any given system, not alone the immediate effect upon the crop, but the ultimate effect upon the soil as well. This is made manifest only by continued manuring along definite lines. Thus, by long-continued comparison of different materials which may be used respectively as sources of any given plant food element, we may hope to determine their real and average relative value, and, by suitable rotation of crops, their relative suitability also for different plants. By continued experiment along definite lines in successive years we may hope, moreover, to discover the relation of season to the fertilizer efficiency of the different fertilizer materials under comparison. With definite knowledge concerning immediate effect upon the crop, ultimate effect upon the soil and differences in effect due to variations in seasons, we shall be in a position to give advice of value both to the farmer seeking to produce crops at lowest cost and to the fertilizer manufacturer. The work carried on in the department during the past season has involved the care of 244 field plots in our various fertilizer and variety tests, 150 closed plots and 245 pots in vegetation experiments. The work in the closed plots and the vegetation experiments serve as valuable checks upon the accuracy of field work, and enable us to extend the scope of our investigations. Besides the care for all this work, we have a grass garden including 48 species and 7 varieties, most of which occupy one square rod each. Our work with poultry has followed the general lines of investigation of earlier years, the principal subject under investigation being the relations of different foods and food combinations to egg production. A detailed report of results obtained will be at this time presented for but a small number of the experiments in progress.

The principal subjects of inquiry discussed, and the more important results, very briefly stated, are as follows: —

I. — To determine the relative value of barnyard manure, nitrate of soda, sulfate of ammonia and dried blood, as sources of nitrogen. The crop of this year was mixed oats and peas for hay; and, on the basis of yield, the nitrogen-furnishing materials rank in the following order: nitrate of soda, dried blood, sulfate of ammonia, and barnyard manure. On the basis of increase, as compared with no-nitrogen plots, taking into account all the crops grown since the experiment began, the materials rank as follows: nitrate of soda, 100 per cent.; dried blood, 68.72 per cent.; sulfate of ammonia, 60.78 per cent.; barnyard manure, 80.58 per cent.

II. — To determine the relative value of muriate as compared with high-grade sulfate of potash for field crops. The results of this year indicate the sulfate to be superior to the muriate for clover, for rhubarb, and for blackberries.

III. — To determine the relative value of different potash salts for field crops. The salts under comparison are high-grade sulfate, low-grade sulfate, kainite, muriate, nitrate, carbonate, and silicate. The crop of this year was soy beans. The different potash salts rank in the following order: carbonate, high-grade sulfate, silicate, nitrate, muriate, low-grade sulfate, and kainite. The crop where the latter salt was used was by far the poorest in the field, being much lower than the crop of the plots to which no potash has been applied for the past eight years.

IV. — To determine the relative value in crop production of a fertilizer mixture rich in potash, as compared with one representing the average of special corn fertilizers purchasable in our markets. The crop of this year was hay, — mixed timothy, red-top and clovers. The crops were substantially equal; but, as the cost of fertilizers is lower where the fertilizer richer in potash is used, the advantage is with that combination of materials.

V. — To determine the relative value in corn and hay production of a moderate application of manure alone, as compared with a smaller application of manure used in combination with 160 pounds of high-grade sulfate of potash per acre. The crop of this year was hay, — mixed timothy, red-top and clovers. The larger average yield was produced on the combination of manure and potash; and, as this combination costs $6.40 less per acre than the larger quantity of manure alone, the advantage in favor of the combination is decisive.

VI. — To determine which is better economy, to spread manure as hauled from the stable during the winter, or to place in a large heap to be spread in spring. This experiment occupies five pairs of plots. The spring application gave the better yield in all cases, but the difference was not sufficiently large to cover the larger cost of the extra handling involved in the case of the manure spread in the spring. The winter of 1904–05, however, was exceptionally favorable to good results from application at that season, as there was little or no wash over the surface.

VII. — To determine the economic result of using in rotation on grass lands: the first year, barnyard manure, 8,000 pounds per acre; the second year, wood ashes, 1 ton per acre; and the third year, bone meal, 600, and muriate of potash, 200, pounds per acre. The average yield of hay during the past season, all three systems of manuring being represented, on a total area of about 9 acres, is at the rate of about 4,840 pounds of hay per acre. The average for the thirteen years during which the experiment has continued, 1893–1905, inclusive, is 6,479 pounds.

VIII. — To determine whether the application of nitrate of soda after the harvesting of the first crop will give a profitable increase in the rowen crop. The increases produced in the four pairs of plots under comparison were relatively small except in one instance. Nitrate applied at the rate of 250 pounds per acre gave an apparent increase of nearly 1 ton of rowen, which is considerably more than sufficient to cover the cost of the nitrate.

IX. — To test the relative value for the production of garden crops of fertilizers supplying respectively nitrogen and potash, when used with manure. The nitrogen fertilizers compared are dried blood, nitrate of soda and sulfate of ammonia. The use of the nitrate is attended with the greatest profit. On the basis of total crops produced, the relative standing of the different nitrogen fertilizers is: for the early crops, nitrate of soda, 100 per cent.; dried blood, 95.67 per cent.; sulfate of ammonia, 63.08 per cent.; for the late crops, nitrate of soda, 100 per cent.; dried blood, 98.77 per cent.; sulfate of ammonia, 79.52 per cent.

The potash salts under comparison are high-grade sulfate and muriate. For the fifteen years the relative standing of these fertilizers is: for the early crops, sulfate of potash, 100 per cent.; muriate of potash, 94.66 per cent.; for the late crops, sulfate of potash, 97.9 per cent.; muriate of potash, 100 per cent.

X. — To determine whether alfalfa is a profitable crop in Massachusetts. A large number of experiments tried during the past eight or ten years indicates that it is quite doubtful whether alfalfa can be successfully grown under our climatic conditions.

XI. — Comparison of different feeds and feed combinations furnishing the essential nutrients in varying proportions for laying hens. The results indicate corn to have superior merit among the different grains for the production of eggs, considered from the standpoint both of total number and economy of production. Rice is somewhat superior in number of eggs produced to corn, but the cost is so great as to render its use inexpedient.

I. — MANURES AND FERTILIZERS FURNISHING NITROGEN COMPARED. (FIELD A.)

To make clear the plan of the experiment, which is continuous, I quote from the seventeenth annual report: —

> The experiments in Field A have two principal objects in view: first, to compare the efficiency (as measured by crop production) of a few standard materials which may be used on the farm as sources of nitrogen; second, to determine to what extent the introduction of a legume will render the application of nitrogen to a succeeding crop of another family unnecessary. The field includes eleven plots of one-tenth acre each. A full description of the plan followed will be found in the twelfth annual report of the Hatch Experiment Station. The materials furnishing nitrogen under comparison are barnyard manure, nitrate of soda, sulfate of ammonia and dried blood. With few and unimportant exceptions, each plot has been manured in the same way since 1890. All the plots annually receive equal and liberal amounts of materials supplying phosphoric acid and potash. Three plots in the field have had no nitrogen applied to them since 1884; the materials under comparison on the other plots in the field are applied in such quantities as to furnish nitrogen at the rate of 45 pounds per acre to each. Barnyard manure is applied to one plot, nitrate of soda to two, sulfate of ammonia to three and dried blood to two plots. The potash applied to these plots is supplied in the form of muriate to six plots, namely, 1, 3, 6, 7, 8 and 9. It is supplied in the form of low-grade sulfate to four plots, namely, 2, 4, 5 and 10.

The crops grown in this experiment previous to this year in the order of their succession have been: oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover, potatoes, soy beans, potatoes, soy beans, potatoes.

The condition of the soil of this field during the last year or two had indicated quite clearly that it would be benefited by liming. Freshly water-slaked lime was used. It was applied by the use of Kemp's manure spreader, adjusted with a view to applying lime as closely as possible at the rate of 1 ton to the acre. The amount actually applied to

1$\frac{1}{10}$ acre was 2,395 pounds, so that the lime was used in slightly greater quantity than intended. The work of the spreader in applying lime is quite satisfactory. There is no difficulty in adjusting it to apply any desired amount with substantial accuracy. Any chance that the amounts applied to the different plots in such experiments as those in progress on Field A will differ is avoided by driving the spreader in applying the lime the full length of the field across the plots.

The crop of this year was oats and peas. The lime was applied on April 26, and plowed in, and Canada peas at the rate of 1½ bushels per acre were sown on April 28, and deeply harrowed in. On April 29 the fertilizers were applied, and harrowed in. The oats were of the Clydesdale variety. They were sown at the rate of 1 bushel to the acre on May 1, and harrowed in. No accidental conditions likely to interfere with the experiment were noted, although the rank growth on the plots receiving nitrogen in the most highly available form (nitrate of soda and sulfate of ammonia) resulted in considerable lodging, which no doubt decreased the yield on those plots.

The rates of yield on the several plots and the source of nitrogen on each are shown in the following table: —

Yield of Oats and Peas per Acre.

Plots.	NITROGEN FERTILIZERS USED.	Hay (Pounds).
0, . .	Barnyard manure, ...	4,950
1, . .	Nitrate of soda (muriate of potash), ...	6,900
2, . .	Nitrate of soda (sulfate of potash), ...	7,000
3, . .	Dried blood (muriate of potash), ...	6,700
4, . .	No nitrogen (sulfate of potash), ...	4,350
5, . .	Sulfate of ammonia (sulfate of potash), ...	5,650
6, . .	Sulfate of ammonia (muriate of potash), ...	6,600
7, . .	No nitrogen (muriate of potash), ...	4,800
8, . .	Sulfate of ammonia (muriate of potash), ...	6,900
9, . .	No nitrogen (muriate of potash), ...	3,900
10, . .	Dried blood (sulfate of potash), ...	6,500

It will be noticed that the yield on the three no-nitrogen plots (4,7,9) is much below the yield obtained on any of the plots where fertilizers supplying nitrogen were used. There was a fair proportion of peas in the crop, but, in spite of the fact that peas are usually able to take a considerable proportion of their nitrogen from the air, it is very clear that it will be unwise, in the case of a mixed crop including a legume and a non-legume, to depend to any great extent upon this atmospheric source of supply. The average yield of the three no-nitrogen plots was at the rate of 4,350 pounds of hay per acre. The average yield of the nitrogen plots was at the rate of 6,400 pounds per acre. Here is a difference of a little more than 1 ton per acre, which is far more than sufficient to cover the cost, $7.85, of the amounts in which such fertilizer was used. It will be noticed, further, that the yield on the plot to which barnyard manure is annually applied is much below that on even the poorest plot to which a nitrogen fertilizer was applied. The manure in question was put on at the time of preparing the soil in the spring, and evidently the nitrogen it contained did not become in large degree available in season to benefit crops making their growth so early in the growing season as oats and peas. The average yields of this year on the several fertilizers are shown in the following table : —

FERTILIZERS USED.	Hay (Pounds).
Average of the no-nitrogen plots (4, 7, 9),	4,350
Average of the nitrate of soda plots (1, 2),	6,950
Average of the dried-blood plots (3, 10),	6,600
Average of the sulfate of ammonia plots (5, 6, 8),	6,383

As the result of experiments previous to this year, it has been found that the materials furnishing nitrogen have produced crops in the following relative amounts : —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	96.02
Dried blood,	90.83
Sulfate of ammonia,	88.62
No nitrogen,	72.11

Similar averages for this year are as follows: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	94.96
Sulfate of ammonia,	91.84
Barnyard manure,	71.22
No nitrogen,	62.60

Combining the results showing relative standing in 1905 with similar figures for all the years previous to 1905, the relative standing is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	94.47
Dried blood,	91.09
Sulfate of ammonia,	88.83
No nitrogen,	71.52

The figures showing relative standing of the different materials furnishing nitrogen as compared with the no-nitrogen plots so far given are based upon the total yield. If we compare the different materials used as sources of nitrogen on the basis of increase in crop rather than on the basis of total product, they rank to date for the entire period of the experiment, 1890 to 1905, inclusive, as follows: —

Relative Increases in Yields (Average for the Sixteen Years).

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	80.58
Dried blood,	68.72
Sulfate of ammonia,	60.78

Whatever the method of comparison, the superiority of the results obtained from the use of nitrate of soda is very apparent. In estimating the significance of the figures, the fact must not be lost sight of that the four different materials, nitrate, dried blood, sulfate of ammonia and barnyard manure, are applied in this experiment in amounts furnishing precisely equal quantities of nitrogen to each plot where they are used. At current prices, a pound of nitrogen can be purchased at lower cost in nitrate of soda than in almost any other material; and the advisability, therefore, of depending largely upon the nitrate as a means of supplying the important element nitrogen, becomes strikingly evident.

II. — THE RELATIVE VALUE OF MURIATE AND HIGH-GRADE SULFATE OF POTASH. (FIELD B.)

This experiment, which has been in progress since 1892, was designed to test the relative value of muriate and high-grade sulfate of potash used continuously upon the same soil. These salts since 1900 have been annually applied at the rate of 250 pounds each per acre. There are ten plots in the field, each containing about 1/7 of an acre. Five of these receive muriate of potash, and these plots alternate with the same number of plots which are yearly manured with sulfate of potash. Each plot in the field is manured annually with fine-ground bone at the rate of 600 pounds per acre. The crops grown in this field this year have included soy beans, celery, asparagus, rhubarb, raspberries, blackberries and clovers. The yields of the three crops, asparagus, raspberries and blackberries, have been small, and the differences in the results on the different potash salts did not appear to be sufficient to be of much significance. There was, however, a very marked difference in the extent to which the blackberry bushes on the two potash salts winter-killed. Those on the plot which has annually received an application of sulfate of potash were killed back much less seriously than the bushes on the muriate of potash plot. There was a marked difference in the growth of the celery on the two potash salts, that on the muriate being much better than that on the sulfate. This fact is reported at this time without comment, as it seems to the writer probable that some accidental cause, not connected directly with the system of manuring, unfavorably influenced the growth on the poorer plot. Six plots in the field have been in clover during the past year. All of these plots were sown to clover in the late summer of 1904, one pair of plots each (muriate and sulfate) with Alsike, Medium and Mammoth clovers. The clover on all plots germinated well, but early showed a very unhealthy condition on the plots occupied both by the Medium and Mammoth red clovers. The young plants early turned yellow and gradually disappeared. So poor was the condition of these varieties of clover this spring that it was decided to plow them up. The unhealthy condition is thought to have been connected with a deficiency of lime in the soil, and these plots accordingly received an application of freshly slaked lime at the rate of about 1 ton to the acre. They were then plowed and reseeded to the same varieties of clover. The crops were cut on August 11, but, being much mixed with weeds, as was to be expected in the case of spring-sown clover, the product was not weighed. The Alsike clover upon the plots sown in the summer of 1904 gave one fair crop.

The yield on the muriate was at the rate of 3,986 pounds per acre; on the sulfate, 4,000 pounds. These figures do not accurately indicate the relative condition of the clover, for the growth on both plots was somewhat mixed with other grasses, which were much more abundant on the muriate of potash than on the sulfate, where the clover was very clearly much superior to that on the other plot. The rhubarb on both potash salts gave a heavy growth. The rates of yield per acre were as follows: —

Muriate v. High-grade Sulfate of Potash (Rhubarb). — Yields per Acre (Pounds).

Fertilizers used.	Stalks.	Leaves.
Muriate of potash, ...	23,148	19,249
Sulfate of potash, ...	23,729	20,344

These yields are much heavier than last year, as the rhubarb is now more fully established, and the difference in favor of the sulfate of potash is still greater than previously.

III. — Comparison of Different Potash Salts for Field Crops. (Field G.)

This experiment for comparison of different potash salts was begun in 1898. The field contains forty plots, of about one-fortieth of an acre each. The plots are fertilized in five series of eight plots each, each series including a no-potash plot and one plot for each of the potash salts under comparison. Those salts are kainite, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and silicate. Each is applied annually to the same plot, and all are used in such amounts as to furnish equal potash to each plot. In the quantities employed the different salts supply annually actual potash at the rate of 165 pounds per acre. All plots are equally manured with materials furnishing fairly liberal amounts of nitrogen and phosphoric acid.[1]

The crops grown in this experiment since 1898 in order of succession up to the present year have been: —

1898. Medium Green soy beans.
1899. Potatoes.
1900. Plots 1–8, cabbage; 9–24, Medium Green soy beans; 25–40, cow peas.
1901. 1–8, wheat; 9–40, corn.
1902. Clover.
1903. Clover.
1904. 1–16, cabbage; 17–40, corn.
1905. Soy beans.

The results with the crops of last year, cabbages and corn, were rather indecisive, and were not reported in detail. The most striking observation in connection with the results of last year was the relatively low yields on the silicate of potash and the relatively high yields on the nitrate and carbonate. The crop in 1905 was the Medium Green soy bean. The season was favorable to the crop, which, with one exception, to be presently noted, appeared to be affected by no disturbing accidental conditions. A circular area, extending entirely across Plot 10 and a short distance into both plots 9 and 11, was early affected by some unknown cause, which within a relatively short time resulted in the death of the plants growing there. It is estimated that the total number of plants in Plot 10 thus destroyed was from one-quarter to one-third of the total number of plants in the plot. The proportion of plants destroyed in plots 9 and 11 was relatively small.

At a period very early in the growth of the crop it was noticed that the leaves on all the plots to which kainite is applied as a fertilizer were abnormal. Practically all the leaves on plants on these plots early became very much crinkled. They were smaller than normal leaves, and there were numerous areas near the margins of some of the leaves where the tissues died. This appearance was repeated with such perfect regularity on each one of the plots (2, 10, 18, 26, 34) to which kainite was applied that it is impossible to doubt that the effect was due to constituents found in this fertilizer. It was clearly physiological in its origin. Whether due to the large amounts of chlorides contained in the kainite applied to these plots we are not at present certain; but, in view of the fact that potassium chloride has in a number of instances been shown to be distinctly inferior as a source of potash for soy beans in comparison with other salts in our experiments, it seems probable that such was the case. The potash salts used on the different plots and the rates of yield of beans per acre are shown in the following table : —

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[1] Sixteenth annual report, Hatch Experiment Station.

Yields per Acre.

Plots.	Potash Salt.	Beans (Bushels).	Straw (Pounds).
1,	No potash,	24.14	2,120
2,	Kainite,	18.62	1,210
3,	High-grade sulfate,	26.90	2,000
4,	Low-grade sulfate,	25.17	1,800
5,	Muriate,	22.41	1,640
6,	Nitrate,	24.14	1,960
7,	Carbonate,	32.41	2,280
8,	Silicate,	22.07	1,540
9,	No potash,	18.79	1,400
10,	Kainite,	11.38	1,600
11,	High-grade sulfate,	21.04	2,080
12,	Low-grade sulfate,	22.42	2,280
13,	Muriate,	22.07	2,240
14,	Nitrate,	25.87	2,800
15,	Carbonate,	28.28	2,700
16,	Silicate,	26.90	2,740
17,	No potash,	24.83	2,380
18,	Kainite,	17.24	1,540
19,	High-grade sulfate,	25.52	1,940
20,	Low-grade sulfate,	24.14	1,760

Yields per Acre — Concluded.

Plots.	POTASH SALT.	Beans (Bushels).	Straw (Pounds).
21, . . .	Muriate, ...	30.69	1,820
22, . . .	Nitrate, ...	26.21	2,160
23, . . .	Carbonate, ...	26.90	2,260
24, . . .	Silicate, ...	26.21	2,080
25, . . .	No potash, ...	22.41	1,780
26, . . .	Kainite, ...	19.31	1,240
27, . . .	High-grade sulfate, ...	31.72	2,080
28, . . .	Low-grade sulfate, ...	25.87	1,760
29, . . .	Muriate, ...	24.48	1,900
30, . . .	Nitrate, ...	15.86	1,240
31, . . .	Carbonate, ...	26.55	1,960
32, . . .	Silicate, ...	23.19	1,600
33, . . .	No potash, ...	23.45	1,800
34, . . .	Kainite, ...	18.26	1,160
35, . . .	High-grade sulfate, ...	24.14	1,820
36, . . .	Low-grade sulfate, ...	16.21	960
37, . . .	Muriate, ...	15.52	1,040
38, . . .	Nitrate, ...	24.83	2,020
39, . . .	Carbonate, ...	24.14	2,240
40, . . .	Silicate, ...	28.62	2,160

The influence of the different potash salts is somewhat more clearly brought out by the table below, which gives the average results for each of the potash salts employed: —

Soy Beans. — Average Yield per Acre.

POTASH SALT.	Beans (Bushels).	Straw (Pounds).
No potash (plots 1, 9, 17, 25, 33), ...	22.72	1,896
Kainite (plots 2, 10, 18, 26, 34), ...	16.96	1,350
High-grade sulfate (plots 3, 11, 19, 27, 35), . . .	25.86	1,984
Low-grade sulfate (plots 4, 12, 20, 28, 36), . . .	22.76	1,712
Muriate (plots 5, 13, 21, 29, 37), ...	23.03	1,728
Nitrate (plots 6, 14, 22, 30, 38), ...	23.38	2,036
Carbonate (plots 7, 15, 23, 31, 39), ...	27.86	2,288
Silicate (plots 8, 16, 24, 32, 40), ...	25.40	2,024

It will be noticed that the average rate of yield on all plots to which potash salts are applied, with the exception of those where kainite is the source of potash, is greater than on the no-potash plots. The average yield on the kainite, on the other hand, is much below the average on the no-potash plots. Examination of the longer table shows that this inferiority of kainite was constant for each of the five plots. Such examination also shows that the variation in relative standing of the plots where each of the different potash salts was used is fairly constant for each. The most marked exception to this rule is found in the case of plots 30, 36 and 37, where the yields are lower than on other plots receiving the same potash salts. This inferiority on these plots appears to have been due to the fact that the stand of plants in them was too thin. A count indicates that the average number of plants in a row in this field is about 120; in Plot 30 it was about 95; in plots 36 and 37 about 45. The potash salt giving the highest yield in this experiment is the carbonate, followed closely by the high-grade sulfate and silicate. The potash salts, other than kainite, containing chlorine (low-grade sulfate and muriate), give yields considerably lower. As neither the carbonate nor the silicate of potash is commonly found in our markets, these having been manufactured in the first instance as fertilizers for tobacco, the practical lesson to be drawn from the experiment is that for the soy bean it is much safer to depend upon the high-grade sulfate as a source of the needed potash than to use any of the potash salts containing chlorine. Neither the carbonate nor the silicate, even if available, would be preferable to the high-grade sulfate, as the cost per unit of potash is much greater than with sulfate. The result of the past season is in agreement with results obtained with this crop in a considerable number of earlier experiments, and it seems impossible to doubt the validity of the conclusion above stated. The advice, therefore, is most strongly given, that, on all soils at least with good retentive qualities and moisture, the sulfate of potash should generally be preferred to muriate or kainite, not only for soy beans, but for clovers and with little doubt for all other legumes as well.

IV. — SPECIAL FERTILIZER *v.* FERTILIZER RICHER IN POTASH.

This experiment has been in progress since 1891. It occupies an acre of ground, divided into four equal plots. The crop from 1891 to 1896, inclusive, was corn; in 1897 and 1898 the crop was mixed grass and clover; in 1899 and 1900 it was corn; in 1901 and 1902, grass and clover; in 1903 and 1904, corn. The land was seeded in the corn in late summer, 1904. The crop harvested this year is hay, — mixed timothy, red-top and clover. The object in this experiment is to test the question whether the special corn fertilizers offered in our markets are of such composition as is best suited for the production in rotation of corn and mixed hay. The plots are numbered from 1 to 4. Plots 1 and 3 yearly receive an application of fertilizers furnishing the same amount of nitrogen, phosphoric acid and potash as would be furnished by 1,800 pounds of fertilizer of the composition of the average of the special corn fertilizers analyzed at this station. This average has changed but little during recent years, and in 1899, since which date we have made no change in the kinds and amounts of fertilizers used, was as follows: —

	Per Cent.
Nitrogen, ...	2.37
Phosphoric acid, ...	10.00
Potash, ...	4.30

The fertilizers used on plots 2 and 4 are substantially the same in amount and kind as recommended in Bulletin No. 58 of this station for corn on soils poor in organic matter. The essential difference in composition between the fertilizer mixtures under comparison is that the mixture used on plots 2 and 4 is richer in potash and much poorer in phosphoric acid than the mixture representing the average market corn fertilizers. The fertilizers applied to the several plots are shown below: —

FERTILIZERS USED.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4 (Pounds Each).
Nitrate of soda,	30.0	50.0
Dried blood,	30.0	–
Dry ground fish,	37.5	50.0
Acid phosphate,	273.0	50.0
Muriate of potash,	37.5	62.5

The following tables show rates of yields per acre of both hay and rowen on the several plots, and the averages for the two systems of manuring: —

Yields per Acre (Pounds).

PLOTS.	Hay.	Rowen.
Plot 1 (lesser potash),	3,960	240
Plot 2 (richer in potash),	3,900	360
Plot 3 (lesser potash),	3,720	400
Plot 4 (richer in potash),	3,720	300

Average Yields per Acre (Pounds).

PLOTS.	Hay.	Rowen.
Plot 1 and 3 (lesser potash),	3,840	320
Plots 2 and 4 (richer in potash),	3,810	330

It will be noticed that the yields under the two systems of manuring, both in hay and rowen, are substantially equal. At current prices, the cost per acre of the fertilizers used on plots 2 and 4 is about $5 less than the cost of the materials used on plots 1 and 3. As we have secured equal crops at a materially lower price, the advantage is clearly with the fertilizer combination richer in potash.

V. — MANURE ALONE *v.* MANURE AND POTASH.

By way of description of this experiment, I cannot do better than to quote from the seventeenth annual report: —

These experiments, which have for their object to show the relative value as indicated by crop production of an average application of manure used alone, as compared with a smaller application of manure used in connection with a potash salt, were begun in 1890. The field used is level, and the soil of comparatively even quality. It is divided into four quarter-acre plots. The crop grown during the years 1890 to 1896, 1899 and 1900, 1903 and 1904, has been corn. In 1897 and 1898, and again in 1901 and 1902, the crop was mixed grass and clover. Where manure is used alone, it is applied at the rate of 6 cords per acre. Where manure is used with potash, the rates of application are: manure, 4 cords; high-grade sulfate of potash, 160 pounds per acre. Manure alone is applied to plots 1 and 3; the lesser quantity of manure and high-grade sulfate of potash to plots 2 and 4. Estimating the manure alone as costing $5 per cord, applied to the land, the money difference in the cost of the materials applied is at the rate of $6.40 per acre, the manure and potash costing that amount less than the larger quantity of manure alone.

Mixed timothy, red-top and clover was sown in late summer in the standing corn of last year. The following tables show the rates of yield on the several plots and the averages under the two systems of manuring: —

Yields per Acre, 1905 (Pounds).

PLOTS.	Hay.	Rowen.
Plot 1 (manure alone),	6,720	1,840
Plot 2 (manure and potash),	5,820	1,200
Plot 3 (manure alone),	6,120	1,720
Plot 4 (manure and potash),	8,580	1,640

Average Yields per Acre (Pounds).

PLOTS.	Hay.	Rowen.
Plots 1 and 3 (manure alone),	6,420	1,780
Plots 2 and 4 (manure and potash),	7,200	1,420

It will be noticed that the average yield on the two plots receiving the smaller quantity of manure and potash is somewhat greater than on the other two plots. Since this combination (4 cords of manure and 160 pounds muriate of potash) costs $6.40 per acre less than the 6 cords of manure, the advantage is decisively in favor of the combination.

VI. — Experiment in the Application of Manure.

This experiment was begun in 1899, and is to be continued for a series of years. It is designed to throw light upon the question as to whether it is economically good policy to spread manure during the late fall and winter and allow it to remain on the surface until spring before plowing under. This method of application is compared with the plan of hauling manure from the stable to the field during the winter and putting it into large compact heaps, from which it is hauled and spread just before plowing in spring. The field in which this experiment is tried slopes moderately to the west. In further description I quote from the seventeenth annual report: —

> To insure even quality of the manure used in the two systems, it is our practice to manure two plots at one time, putting the loads of manure as hauled to the field alternately upon the two, in the one case spreading, but in the other putting a sufficient number of loads to provide for the entire plot into one large heap. We are using in this experiment five large plots, each of which is subdivided into two subplots. For one of these subplots the manure is spread when hauled out, for the other it is put into a large heap. The area of these subplots is about one-quarter of an acre, and to each the amount of manure applied is 11,096 pounds. The manure from well-fed milch cows is used upon eight subplots, and horse manure on two. The manure used in this experiment is applied at different dates during the winter, our practice being to allow the manure to accumulate in the pits from which it is taken until there is a sufficient quantity for at least two subplots. The condition of the soil at the time of application and the nature of the weather which follows must necessarily differ in the different experiments; and these differences, together with the difference in the dates of application above referred to, no doubt in a measure account for the variation in the results of the two systems noticed on the different plots.

The crop raised in this field last year was mixed corn and soy beans for ensilage. After the harvest of this crop the field was well harrowed and sown to rye. This crop, which was intended for cover, germinated but poorly and made only a feeble growth. The crop of 1905 was corn, — a number of different varieties received for comparison from the United States Department of Agriculture, and Sibley's Pride of the North of our own growing. These varieties were so arranged that each plot and subplot had equal areas of each. The soil was thoroughly prepared by plowing and harrowing, and the seed was sown on May 19. Soil and seasonal conditions were favorable, and the growth was uninfluenced, so far as could be recognized, by accidental conditions. A number of varieties sown showed relatively low productive capacity, and the final yield was lower than is usual in this section on well-manured land of similar quality. The rates of yield per acre and the relative standing of the several plots are shown in the following tables: —

Corn and Stover. — Actual Yields (Rates per Acre).

PLOTS.	NORTH HALF, WINTER APPLICATION.			SOUTH HALF, SPRING APPLICATION.		
	Stover (Pounds).	Hard Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).	Hard Corn (Bushels).	Soft Corn (Bushels).
1, ...	7,347	31.51	3.21	7,862	32.16	2.45
2, ...	7,150	25.96	2.99	7,763	32.08	4.00
3, ...	6,806	22.13	4.36	7,713	27.25	3.53
4, ...	7,447	24.44	3.06	8,309	29.20	2.85
5, ...	7,637	30.46	2.34	8,026	32.48	2.31

Corn and Stover. — Relative Yields (Per Cent.).

PLOTS.	NORTH HALF, WINTER APPLICATION.		SOUTH HALF, SPRING APPLICATION.	
	Stover.	Hard Corn.	Stover.	Hard Corn.
1, ...	100	100	107.0	102.1
2, ...	100	100	108.6	123.6
3, ...	100	100	113.3	123.1
4, ...	100	100	111.6	119.5
5, ...	100	100	105.1	106.4

It will be noticed that in every instance spring manuring has given a larger yield both of stover and of hard corn than winter application. This result is in general agreement with those of earlier years, but the differences as indicated by the relative yields are comparatively small. The winter of 1904 and 1905 was characterized by uniform temperatures, fairly deep and continuous snow cover and absence of thaws. Such conditions are of course favorable to winter application, and the above-mentioned peculiarities of season perhaps account for the smaller relative differences in yield this year.

The system of manuring designated as spring application involves, as will have been noticed by the reader, twice handling, while in winter application the manure is handled but once. Spring application, therefore, costs more than winter application. As the result of our experience, we estimate the money difference to amount to $4.80 per acre. The average difference in the value of crops this year in favor of spring application, estimating stover to be worth $5 per ton and the corn as husked 50 cents per bushel, amounts to only $3.49 per acre, — a sum insufficient to cover the increased cost of spring application. Even on Plot 3, where the difference in favor of spring application is greatest, the money difference in value of the crops on the same basis as before is only $4.81, which barely covers the increased cost of application. The results for this season, therefore, economically considered, indicate that spreading the manure as taken from the stable in the fall or winter is to be preferred.

VII. — Experiment in manuring Grass Land.

The plan of this experiment, which has continued now for thirteen years, will be made clear by quoting from the sixteenth annual report: —

> In this experiment, which has continued since 1893, the purpose is to test a system of using manures in rotation for the production of grass. The area used in the experiment is about 9 acres. It is divided into three approximately equal plots. The plan is to apply to each plot one year barnyard manure,

the next year wood ashes, and the third year fine-ground bone and muriate of potash. As we have three plots, the system of manuring has been so arranged that every year we have a plot illustrating the results of each of the applications under trial. The rates at which the several manures are employed are as follows: barnyard manure, 8 tons; wood ashes, 1 ton; ground bone, 600 pounds; and muriate of potash, 200 pounds, per acre. The manure is always applied in the fall; ashes and the bone and potash in early spring.

The past season has been rather unfavorable for the production of large yields of hay, as there was a considerable deficiency in both spring and summer rainfall. The yields of hay and rowen and the total yields for each system of manuring were at the following rates per acre: —

FERTILIZERS USED.	Hay (Pounds).	Rowen (Pounds).	Totals (Pounds).
Barnyard manure, ...	3,738	1,210	4,948
Bone and potash, ...	3,326	1,249	4,575
Wood ashes, ...	3,816	1,047	4,863

The average yield of the entire area this year was 4,840 pounds per acre. The average yield of the entire area from 1893 to 1904, inclusive, has been 6,718 pounds per acre. The average yield from 1893 to 1905, inclusive, has been 6,479 pounds per acre. The average yields under the different systems of top-dressing have been as follows: —

	Pounds per Acre.
When top-dressed with manure, ...	6,866
When top-dressed with wood ashes, ...	6,193
When top-dressed with bone and potash, . . .	6,524

It will be noticed that the average yields of the entire area for this year are much below similar averages for the period.

VIII. — NITRATE OF SODA FOR ROWEN.

For the past five years we have been experimenting in one of our fields for the purpose of determining whether nitrate of soda applied soon after the first crop is cut will give a profitable increase in the rowen crop. The field where this experiment has been tried was seeded to pure timothy in the fall of 1897. The growth is now considerably mixed with clover, which has been gradually coming in. The whole field is uniformly fertilized for the first crop. The materials applied are usually put on in early spring at the following rates per acre : nitrate of soda, 150 pounds ; muriate of potash, 200 pounds ; fine-ground bone, 400 pounds. This application usually gives us a good crop. The area of the field is a little more than 3 acres. The rate of yield in the first crop this year was 4,471 pounds of well-cured hay per acre. In this field eight equal plots, containing almost exactly ⅓ acre each, have been laid out. Alternate plots in the series of eight receive annually a top-dressing of nitrate of soda. For the past two years, in order that the nitrate may be more uniformly spread, we have mixed the quantity to be applied to each plot with sufficient basic slag meal to constitute an application at the rate of 400 pounds per acre. To equalize conditions on the alternate plots to which no nitrate is applied, the basic slag meal is applied to all of these at the same rate. The rates of application for the fertilizers on the several plots per acre and the yields are shown in the table : —

Nitrate of Soda for Rowen.

Plots.	FERTILIZERS USED (RATES PER ACRE).	Yield (Pounds).	Increase per Acre (Pounds).
1,	Slag meal, 400 pounds,	975	–
2,	Slag meal, 400 pounds; nitrate of soda, 150 pounds.	1,127	228
3,	Slag meal, 400 pounds,	822	–
4,	Slag meal, 400 pounds; nitrate of soda, 150 pounds.	1,036	305
5,	Slag meal, 400 pounds,	640	–
6,	Slag meal, 400 pounds; nitrate of soda, 200 pounds.	1,340	486
7,	Slag meal, 400 pounds,	1,067	–
8,	Slag meal, 400 pounds; nitrate of soda, 250 pounds.	3,009	1,942

It will be noticed that the nitrate of soda wherever applied has given an increase in the crop. This increase is relatively small in all the plots except Plot 8, where it is at the rate of nearly 1 ton per acre. During all the years that this experiment has been tried on this land it has been found that the yield on Plot 8 has been much the largest in the fall. True, this receives the heaviest application of nitrate, but it is not believed that the superiority in yield is entirely due to this difference. The moisture conditions are more favorable to growth during the late summer in this plot than in the others. During the five years that this experiment in the use of nitrate of soda for the rowen crop has been tried on this field, it has seemed to give increases sufficient to make the application profitable only in two trials; and, on the whole, the results of our experiments are not favorable to the conclusion that it will usually be found profitable to use nitrate of soda for the rowen crop. The soil in this field is a strong and retentive loam. It is, of course, quite possible that on soils of different character the results of the use of nitrate for rowen will be more favorable.

IX. — Fertilizers for Garden Crops. (Field C.)

In this experiment the principal object in view is to study the effect of some of the standard fertilizing materials upon the yield and quality of garden crops. During the earlier years of the experiment, 1891 to 1897 inclusive, fertilizers alone were applied to the land. It was then decided that, since market gardeners as a rule employ large quantities of manure, the value of the experiment to those engaged in that branch of agriculture would be increased by applying manure equally to all the plots, while still continuing the application of fertilizers. During the earlier years of the experiment there were but six plots, on all of which fertilizers were used. With the change in system alluded to a seventh plot was introduced, and to all of the seven plots stable manure at the rate of 30 tons per acre has since been annually applied. It is intended that the seventh plot, on which manure alone is applied, shall serve as a basis of comparison with the others, in order that we may learn whether, and, if so, to what extent, any fertilizers prove beneficial. The seventh plot immediately adjoins the others, but previous to its inclusion in this experiment it had been manured somewhat differently. For the first few years the product on manure alone on this plot exceeded the product with equal manure and fertilizers on the other plots. This initial superiority is gradually disappearing, and the product of most of the crops where the fertilizers as well as manure are used now exceeds that upon the seventh plot, where manure only is used. It is possible that the seventh plot does not even yet serve as a fair basis for comparison ; but the following crops on most of the plots, where fertilizers in addition to manure are used, have given yields sufficiently greater than those produced where manure alone is used to much more than pay for the cost of the fertilizers, viz. : asparagus, rhubarb, peas, squashes, tomatoes and table beets. It should be pointed out, however, that such increase was in most cases very small where sulfate of ammonia is one of the fertilizer materials used. Indeed, with asparagus the combination of manure and fertilizers containing sulfate of ammonia gave a smaller yield than manure alone. With tomatoes the increased yield was mainly confined to green fruit. The fertilizers did not materially increase the yield of ripe fruit as compared with the yield obtained on manure alone. Some crops showed no increase at all on the plots where fertilizers were added to the manure. Among these were celery and turnips, while cabbages gave either no increase at all or one which was insignificant.

Practically all important out-door garden crops have been grown in rotation upon each plot, and each crop during several years. The crops so far grown are as follows: spinach, lettuce, onions, garden peas, table beets, early and late cabbages, potatoes, tomatoes, squashes, cucumbers, turnips, sweet corn, celery and strawberries. One row each of asparagus and rhubarb was set in each plot in 1902. The first cuttings were made last year.

As stated in my last annual report, these "experiments have been planned with reference to throwing light especially upon two points : *A*. The relative value of nitrate of soda, sulfate of ammonia, and dried blood used as sources of nitrogen. *B*. The relative value of sulfate of potash and muriate of potash. These two points will be separately discussed."

A. — The Relative Value of Nitrate of Soda, Sulfate of Ammonia and Dried Blood as Sources of Nitrogen.

The three fertilizers under consideration have from the first been applied in such amounts as to furnish nitrogen at the rate of 60 pounds per acre to each plot. Each fertilizer is always applied to the same plot. To furnish 60 pounds of nitrogen, the application of the fertilizers at about the following rates per acre is required: —

	Pounds.
Nitrate of soda,	375
Sulfate of ammonia,	300
Dried blood,	650

Each of these fertilizers is used on two plots, on one of which the source of the potash is the sulfate, on the other the muriate, in both cases in such quantities as to furnish equal actual potash. In addition to the nitrogen and potash fertilizers, dissolved boneblack is applied at the rate of 320 pounds per acre to all plots. The amount of actual potash applied is at the rate of 120 pounds per acre; the amount of actual phosphoric acid at the rate of 50.4 pounds per acre. The source of the potash used affects the results on some of the crops in a marked degree. This is especially the case where sulfate of ammonia is the source of nitrogen.

The results obtained previous to this year may be summarized as follows: —

For the early crops, *i.e.*, the crops making most of their growth before mid-summer, including onions, lettuce, table beets, garden peas, spinach, early cabbages and strawberries, the nitrate of soda has been found the most effective source of nitrogen.[1]

The relative standing of the different nitrogen fertilizers, as measured by the total yields, including leaves, vines and tops, as well as the marketable product, is as follows for the early crops: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	95.64
Sulfate of ammonia,	60.95

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[1] Sixteenth annual report, Hatch Experiment Station, p. 124.

For the late crops, including late cabbages, celery, tomatoes, turnips and squashes: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	98.88
Sulfate of ammonia,	78.74

The relative average standing of the sulfate and muriate of potash, as indicated by the total yield of all crops grown in Field C previous to this year, is shown in the following table: —

FERTILIZERS USED.	Early Crops (Per Cent.).	Late Crops (Per Cent.).
Sulfate of potash,	100.00	98.32
Muriate of potash,	94.04	100.00

For the past year the relative standing of the nitrogen fertilizers for the early crops, including asparagus, rhubarb, strawberries, peas and table beets, is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	96.11
Sulfate of ammonia,	92.83

For the late crops, including cabbages, celery, tomatoes, turnips and squashes, the relative standing is: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	97.22
Sulfate of ammonia,	90.51

Combining the results for 1905 with the fourteen previous years, the relative standing of the nitrogen fertilizers is: —

For the early crops: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	95.67
Sulfate of ammonia,	63.08

For the late crops: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	98.77
Sulfate of ammonia,	79.52

The relative standing of the potash salts for the present year is: —

For the early crops: —

	Per Cent.
Sulfate of potash,	96.52
Muriate of potash,	100.00

For the late crops: —

	Per Cent.
Sulfate of potash,	92.08
Muriate of potash,	100.00

Combining the relative standing of the potash salts for 1905 with the figures indicating relative standing for the fourteen previous years, the relative standing is: —

For the early crops: —

	Per Cent.
Sulfate of potash,	100.00
Muriate of potash,	94.66

For the late crops: —

	Per Cent.
Sulfate of potash,	97.90
Muriate of potash,	100.00

The results of the experiments for this year will not be reported in detail. The following points are worthy of mention: —

1. Nitrate of soda appears to be the best source of nitrogen for asparagus, table beets, cabbages and squashes.

2. Dried blood as the source of nitrogen has given the largest crops in the case of strawberries, peas, tomatoes and celery.

3. Sulfate of potash as the source of potash seems to be superior for asparagus, peas, beets and cabbages.

4. Muriate of potash gives results superior to those obtained with the sulfate for rhubarb, strawberries, squashes, tomatoes and celery.

5. Sulfate of ammonia for practically all crops appears to have been the poorest material used as a source of nitrogen.

X. — Alfalfa.

Our experiments with alfalfa have been continued both upon our own grounds and those of a few selected farms in different parts of the State. We are bringing to bear upon these experiments information in regard to successful methods from every possible source. We find in all cases a distinct benefit from a heavy initial application of lime. We have used from 2,000 to 3,000 pounds per acre. We are enriching soils already naturally good by heavy applications both of manures and fertilizers, using materials which experience has proved best. We are also giving the soil a most thorough preparatory tillage. It has usually been fall-plowed, and in addition it is plowed in the spring, and repeatedly harrowed to destroy weeds which start in the early part of the season. We have tried inoculating the soil both with earth obtained from a field in New York, where alfalfa is successfully grown, and with the cultures sent out by the Department of Agriculture and prepared by private firms. We have not attained such degree of success as justifies us in recommending the crop. We have occasionally got a fair stand of alfalfa, but in all cases the winters prove more or less injurious. In the course of a few years the alfalfa is mostly crowded out by grasses and clovers. The alfalfa almost every year suffers from leaf spot, which tends to cut down the yield.

We have found a very distinct benefit from the inoculation with earth from the New York alfalfa field. We have not found an equally distinct benefit to follow inoculation with any of the cultures; and, although we are not as yet ready to make a final report, it should be here remarked that the most careful experiments on the use of these cultures in sterilized soils, under conditions calculated to give accurate results, indicate that they have little if any value.

In our various experiments alfalfa has been tried on a wide variety of soils. We have had a quarter of an acre field upon a coarse-textured soil upon a farm in this neighborhood where there is never any standing water within 50 to 60 feet of the surface. Even on this soil the alfalfa, although it did fairly well for a year, has been injured by successive winters, until it is at the present time almost ruined.

In this connection I call attention further to the fact that Mr. D. S. Bliss of the Department of Agriculture, who has been making special efforts to promote the introduction of alfalfa into New England, and who has travelled extensively for the purpose of studying the results obtained, now speaks very discouragingly as to the outlook in general.

In conclusion, while we are not inclined to discourage experiments with alfalfa, we do wish most emphatically to caution against engaging in these experiments upon an extended scale, for we feel that disappointment is almost inevitable.

XI. — Poultry Experiments.

Our work with poultry during the past year has had the same general purpose in view as in former years, namely, to throw light on the question of the proper selection of feeds for laying fowls. The fowls used in the experiments were pullets of our own raising, and matched flocks have been kept, as in former years, each in a house by itself, all the houses being of precisely similar dimensions and construction.

1. The two flocks in houses Nos. 1 and 2 have been fed on rations characterized by high content both of ash and fat and low fiber. The deficiency of wheat in fat as compared with corn is made up in the ration fed to the fowls in House No. 1 by the use of corn oil, the total amount of fat in the foods used being substantially the same for the two rations. This experiment, therefore, in a general way affords opportunity to test the relative value for egg production of wheat and corn. The ration fed the fowls in House No. 1 contains a relatively high percentage of protein, and has a narrow nutritive ratio. The ration used in House No. 2 contains a relatively low percentage of protein, and has a wide nutritive ratio. The animal food used in both these rations was beef scraps. The following results were obtained: for the first period, March 2 to May 12, inclusive, the wheat ration produced eggs at the average rate of .39 per hen day, the

corn ration at the rate of .45 per hen day; in other words, 100 hens would have laid 39 eggs per day on the wheat ration and 45 eggs per day on the corn ration. For the second period, May 13 to September 23, inclusive, the wheat ration produced an average of .31 eggs per hen day, the corn ration at the rate of .41 eggs per hen day; in other words, during the summer period 100 hens would have laid 31 eggs per day on the wheat ration and 41 eggs per day on the corn ration. The average food cost per egg produced was: for the wheat ration 1.036 cents, for the corn ration .749 cents, for the first period; while for the second period the cost per egg on the wheat ration was .895 cents and for the corn ration .703. The gross cost of the food on the wheat ration varied from about .26 cents to .37 cents per day for each fowl; while on the corn ration the cost varied from .27 cents to .30 cents per day. The number of eggs on the corn ration was considerably greater than on the other, and the cost per egg was much smaller. This result is in agreement with the results of most of the similar experiments which we have tried in earlier years. We are certainly justified in the conclusion that corn has superior merits for egg production as compared with wheat.

2. The rations fed to the fowls in pens Nos. 3 and 4 were characterized by relatively high ash and low fiber content. Milk albumen was used as the source of animal food on account of the low percentage of fat it contains; and the rations fed to the fowls in both of these pens were characterized by much lower fat content than the rations fed to the fowls in pens Nos. 1 and 2. As in the first set of comparisons, the fat content of the two rations used in pens Nos. 3 and 4 was equalized by the addition of corn oil to the one naturally lower in fat. In this experiment, as in the first, wheat was the leading whole grain in the ration fed to the fowls in one house (No. 3); corn the leading whole grain used in the other house (No. 4). The results with the fowls in these houses, like the results obtained in houses Nos. 1 and 2, afford a basis for estimating the relative value of wheat and corn, but with a relatively low percentage of fat in both. The egg product in this experiment was as fol-

lows: for the first period, March 3 to May 12, inclusive, the wheat ration produced eggs at the average rate of .41 per hen day, the corn ration .39 per hen day; or, in other words, 100 hens would have laid on the wheat ration 41 eggs, on the corn ration 39 eggs, per day. For the second period, May 13 to September 23, inclusive, the wheat ration gave an average of .35 eggs per hen day, the corn ration .31; or, in other words, respectively for the wheat ration, an average of 35 eggs per hundred hens daily, and for the corn an average of 31 eggs. The food cost of the eggs in this experiment was as follows: for the wheat ration during the summer period, .845 cents per egg; for the spring period, 1 cent per egg. For the corn ration, the food cost per egg was .871 cents for the summer period; .942 cents for the spring period. The cost of food per hen daily on the wheat ration varied from .273 to .372 cents; for the corn ration, from .248 to .333 cents. In this experiment the wheat ration gave a somewhat better egg yield than corn, but at a higher average cost per egg. The experiment indicates, therefore, that, unless the fat content of the ration is relatively high, the more starchy foods are not sufficient to produce a satisfactory egg yield, and the product falls below that obtained from feeding a ration higher in protein.

3. The fowls in houses Nos. 5 and 6 were fed rations in both cases characterized by low protein, high ash and high fat content, the deficiency of fat in the grains selected being made up by the use of corn oil. The fowls in Pen No. 5 were fed grains, including oats and oat feed, characterized by a high proportion of fiber. Those in Pen No. 6 were fed grains among which rice was prominent, characterized by a low percentage of fiber. The experiment in these houses, then, was calculated to throw light upon the influence of fiber on egg production, the nutritive ratio in the two houses being substantially the same, — about 1 to 6.5. In these houses beef scraps was the animal food used. The results were as follows: For the period March 2 to May 12, inclusive, the egg production was: for the oat ration (high fiber) .40 eggs per hen day, for the rice ration (low fiber) .42 eggs per hen day; or, in other words, from 100 hens

daily respectively 40 and 42 eggs. For the second period, May 13 to September 23, inclusive, the averages were: on the oat ration .38 eggs per hen day, on the rice ration .46 eggs per hen day; or, from 100 hens daily respectively 38 and 46 eggs. The food cost of the eggs has been as follows: for the oat ration during the first period 1.019 cents, for the second period .935 cents; for the rice ration for the first period 1.103 cents, for the second period 1.048 cents. The cost of food per hen per day has varied for the oat ration from .32 to .40 cents; for the rice ration from .412 cents to .423 cents per day. The rice ration, as last year, has given a very satisfactory yield of eggs, but, as was then stated, its high price at the present time renders it poor economy to use it. We are employing it in these experiments because it contains less fiber than any other grain, and we are trying to throw light upon the influence of fiber in egg production. The indication this year, as last, is very clear that this influence is unfavorable.

The nutritive ratios in the food combinations used in the different experiments of the past year have been as follows: for the rations where wheat is compared with corn with beef scraps for animal food and high fat content, — for the wheat ration, between 1 to 4.57 and 4.26; for the corn ration, between 1 to 6.69 and 5.81; for the experiment in which wheat is compared with corn with milk albumen and beef scraps for animal food, — for the wheat ration, between 1 to 4.03 and 4.54; for the corn ration, 1 to 6.28 and 5.84; in the experiment in which oats and rice have been compared with high fat content, — for the oats, between 1 to 5.88 and 6.49; for the rice, between 1 to 5.84 and 6.53.

Our experiments clearly do not support the view that a narrow nutritive ratio is essential to good egg production.

REPORT OF THE HORTICULTURIST.

F. A. WAUGH.

The work of the division of horticulture for the past year has followed the lines announced in previous reports. It has been concerned chiefly with the propagation of plants, more especially dwarf fruit trees, with problems in pruning, and with the systematic study of varieties. During the year some interesting experiments in the growing of mushrooms have been under way. There follows herewith a report of progress in the experiments in pruning peach trees of bearing age.

Pruning Peach Trees.

A year ago this department made a report on experiments in pruning peach trees.[1] Another year has thrown new evidence on the problems involved, so it seems best to take up the subject again. In the mean time the trees have borne a considerable crop of fruit, and their behavior under this load has been particularly interesting.

Last year's report dealt with various problems, one of which was the practice of pruning frozen peach trees to help their recovery. Briefly stated, the experiment comprised four methods of treatment, as follows: (*a*) no pruning; (*b*) moderate pruning; (*c*) severe heading back; (*d*) cutting back to stubs, or "dehorning." The results of these various methods of pruning, as developed up to the time of making last year's report (December, 1904), showed that moderate pruning was to be preferred. It may be said at once that this general conclusion stands without much modification, though the severely pruned trees made a relatively better showing under the stress of a good crop of fruit.

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[1] Hatch Experiment Station, seventeenth annual report, p. 162 (1905).

Perhaps the fact most obviously developed by the year's experience is that the trees were more severely injured by the freezes of 1902–03 and 1903–04 than had been supposed. From week to week one tree after another broke down or split down or lost large branches, through the stress of winds or growing fruit crop. As each successive tree broke down, it was plainly to be seen that the wood had been seriously injured by freezing, and that it had not recovered. Though the tree kept on growing, adding fresh and healthy outer layers of wood, the interior was dead and decaying. In many cases this decay was serious, and had extended through considerable areas of tissue. Many fungi (mostly saprophytes such as feed on dead wood) had gained a foothold, and seemed to be out-thriving the peach trees.

These evidences of decay, especially the larger fungi (polypori, etc.), were most conspicuous on the "dehorned" trees. A few of these trees have finally succumbed during the summer of 1905, and it is now plainer than it was a year ago that this method of treating severely frozen peach trees is not to be recommended. An additional drawback lay in the fact that the trees bore little or no fruit in 1905, while all the other trees in the experiment bore a good crop.

Perhaps a word of explanation should be added to this statement of the case. This method of pruning peach trees back to mere stubs has its uses, as in renewing the head when a tree is to be rebudded to a new variety. It can be successfully carried out, but only on vigorous and comparatively young trees. Trees weakened by freezing are precisely the ones which cannot respond to such vigorous treatment.

Coming next to the trees severely headed back (from which practically all the one-year-old wood was removed in the spring of 1905), we find conditions much better. There are some manifest evidences of the injury received during the freezes of two and three winters ago, some broken limbs and some growth of saprophytic fungi; but the trees show strong, sturdy tops, with a very satisfactory annual growth for 1905. The trees bore a good crop of fruit in 1905, and are in the best condition of any in the orchard for carrying another crop in 1906. While trees severely headed back recovered less readily from the effects of freezing, those which finally bore the crop made distinctly better growth for the pruning.

The trees lightly pruned were cut back only a part of the previous year's annual growth, — from one-third to one-half. The largest percentage of recovery was shown by these trees, and they bore slightly larger crops of fruit in 1905 than any of the others. On the other hand, there appeared to be more breakage of large branches, the heads are left in less satisfactory form than on trees severely headed back, and the prospect for carrying a good crop in 1906 seems to be slightly less.

The trees left without pruning are now distinctly the poorest in the orchard, with the exception only of those that were "dehorned." The percentage of loss was high, the crop of 1905 was inferior to that on the pruned trees, and the present condition of these trees is unsatisfactory.

As the result of this experiment, the following practice would seem to be indicated : —

1. Prune peach trees moderately, removing not more than one-third to one-half the previous year's annual growth, when the wood has been injured by freezing.

2. When only the fruit buds are killed, the wood being uninjured and the trees in good condition, prune severely, cutting back the annual growth to two or three buds. It may be expedient to cut some branches back even into two or three year old wood.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.[1]

CHARLES A. GOESSMANN.

Assistants: HENRI D. HASKINS, EDWARD G. PROULX, E. T. LADD.

PART I. — Report on Official Inspection of Commercial Fertilizers.

PART II. — Report on General Work in the Chemical Laboratory.

PART I. — REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS DURING THE SEASON OF 1905.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 64; of these, 36 have offices for the general distribution of their goods in Massachusetts, 9 in New York, 6 in Connecticut, 3 in Vermont, 2 in Ohio, 1 in Rhode Island, 1 in Maryland, 1 in Tennessee, 1 in Arkansas, 1 in Missouri, 1 in Canada, 1 in New Jersey and 1 in Pennsylvania.

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[1] See also tables in Appendix.

Three hundred and twenty-six brands of fertilizers and agricultural chemicals have been licensed in Massachusetts during the year. Five hundred and seventy-four samples of fertilizers have been collected up to the present time, in our general markets, by experienced assistants in the station. Five hundred and eleven samples had been analyzed at the beginning of December, 1905, representing 313 distinct brands of fertilizers. These analyses were published in two bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 104, July; No. 107, November, 1905. The analyses of other officially collected samples of fertilizers not included in these two bulletins will be published in our next bulletin, in March, 1906. About the same number of fertilizers were licensed in Massachusetts during the year as in 1904. The results of our inspection work show 18 more samples analyzed during the season than for the previous year.

The following table gives a brief abstract of the results of analyses of the official commercial fertilizers in comparison with the year previous: —

	1904.	**1905.**
(*a*) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee, .	7	3
Number with two elements above the highest guarantee, . . .	32	16
Number with one element above the highest guarantee, ...	111	83
Number with three elements between the lowest and highest guarantee,	190	203
Number with two elements between the lowest and highest guarantee,	146	138
Number with one element between the lowest and highest guarantee, .	48	38
Number with three elements below the lowest guarantee, . . .	none	1
Number with two elements below the lowest guarantee, ...	12	25
Number with one element below the lowest guarantee, ...	103	92
(*b*) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee, . . .	8	3
Number with one element above the highest guarantee, ...	16	29
Number with two elements between the lowest and highest guarantee,	20	13
Number with one element between the lowest and highest guarantee, .	19	23
Number with two elements below the lowest guarantee, ...	1	5
Number with one element below the lowest guarantee, ...	15	21
(*c*) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee, ...	16	4
Number between the lowest and highest guarantee, ...	24	25
Number below the lowest guarantee, ...	13	19

From the above table it will be seen that the quality of the licensed fertilizers during the past year has not been up to the usual standard.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1904 and 1905 (Cents per Pound).

	1904.	**1905.**
Nitrogen in ammonia salts,	17.50	17.50
Nitrogen in nitrates,	16.00	17.00
Organic nitrogen in dry and fine-ground fish, meat, blood, and in high-grade mixed fertilizers,	17.50	18.50
Organic nitrogen in fine bone and tankage,	17.00	18.00
Organic nitrogen in coarse bone and tankage,	12.50	13.00
Phosphoric acid soluble in water,	4.50	4.50
Phosphoric acid soluble in ammonium citrate,	4.00	4.00
Phosphoric acid in fine-ground fish, bone and tankage,	4.00	4.00
Phosphoric acid in cotton-seed meal, castor pomace and wood ashes,	4.00	4.00
Phosphoric acid in coarse fish, bone and tankage,	3.00	3.00
Phosphoric acid insoluble (in water and in neutral citrate of ammonia) in mixed fertilizers,	2.00	2.00
Potash as sulfate, free from chlorides,	5.00	5.00
Potash as muriate (chloride),	4.25	4.25
Potash as carbonate,	–	8.00

A comparison of the market cost of the three essential elements of plant food for 1905 with the previous year shows the only variation to be in the various forms of nitrogen compounds: nitrogen in the form of nitrates, and the higher grades of organic nitrogen, including nitrogen in high-grade mixed fertilizers, is a cent higher per pound; while the medium and lower grades of organic nitrogen also show an increased cost of one-half cent per pound. All nitrogen compounds, with the exception of ammoniates, show somewhat of an increase in cost as compared with 1904.

The above schedule of trade values was adopted by representatives of the Massachusetts, Connecticut, Rhode Island, Maine, Vermont and New Jersey experiment stations at a conference held during the month of March, 1905, and is based upon quotations in the fertilizer market in centers of distribution in New England, New York and New Jersey during the six months preceding March, 1905, and refers to the current market prices, in ton lots, of the leading standard raw materials furnishing nitrogen, phosphoric acid and potassium oxide, and which go to make up our commercial fertilizers.

Table A, on the following page, gives the average composition of licensed fertilizers for 1905; Table B gives a compilation of analyses showing the average percentages, as well as the maximum and minimum percentages, of the three essential elements of plant food found in the so-called special crop fertilizers put out by the different manufacturers. This latter table shows how unsafe it is to be guided wholly by trade name when selecting a fertilizer for any special crop. Out of the several hundred fertilizers that are annually offered for sale in the general markets in Massachusetts, it becomes no easy matter for the farmer to select to meet his requirements in cases of the ready factory-mixed goods. No infallible rule can be laid down, as soil conditions vary so widely, and so much depends upon crop rotation. It is safe to say, however, that the higher-grade fertilizers are the most economical ones to buy. Those fertilizers should be purchased which furnish the most nitrogen, potash and phosphoric acid in a suitable and available form for the same money.

TABLE A. — *Average Analysis of Officially Collected Fertilizers for 1905 (Per Cent.).*

NATURE OF MATERIAL.	Moisture.	NITROGEN IN ONE HUNDRED POUNDS.		PHOSPHORIC ACID IN ONE HUNDRED POUNDS.							POTASSIUM OXIDE IN ONE HUNDRED POUNDS.	
							TOTAL.		AVAILABLE.			
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
Complete fertilizer,	10.79	2.74	2.66	4.24	3.63	2.42	10.24	9.13	7.87	7.07	5.11	4.81
Ground bone,	4.99	3.18	2.98	.15	10.47	14.75	25.16	26.80	10.62	6.00	–	–
Tankage,	9.91	5.82	5.54	.45	9.17	6.49	16.11	12.72	9.62	–	–	–
Dry ground fish,	9.13	9.75	8.21	–	5.14	3.15	6.52	7.43	5.14	–	–	–
Dissolved bone-black,	9.06	–	–	7.65	6.94	2.71	17.30	16.00	14.59	15.00	–	–
Dissolved bone,	10.56	2.81	3.00	1.02	9.12	6.02	16.16	18.00	10.14	13.00	–	–
Acid phosphate,	9.78	–	–	8.41	4.17	1.47	14.08	8.50	12.58	9.00	–	–
Wood ashes,	5.27	–	–	–	–	–	–	–	–	–	–	–
Cotton-seed meal,	6.06	6.70	7.64	–	–	–	1.51	1.00	–	–	5.33	4.40
Flax meal,	7.25	5.74	5.92	–	–	–	–	–	–	–	–	–
Nitrate of soda,	2.38	15.75	15.22	–	–	–	–	–	–	–	–	–
Sulfate of ammonia,	1.25	20.49	19.50	–	–	–	–	–	–	–	–	–
High-grade sulfate of potash,	3.06	–	–	–	–	–	–	–	–	–	49.66	49.42
Muriate of potash,	1.96	–	–	–	–	–	–	–	–	–	50.26	50.13
Dried blood,	9.20	10.11	9.50	–	–	–	1.66	–	–	–	–	–
Kainit,	1.52	–	–	–	–	–	–	–	–	–	12.79	12.00
Castor pomace,	8.26	5.27	4.74	–	–	–	–	–	–	–	–	–
Carbonate potash,	1.95	–	–	–	–	–	–	–	–	–	64.00	64.71
Vegetable potash,	2.85	–	–	–	–	–	–	–	–	–	23.96	25.00
Sulfate potash-magnesia,	1.25	–	–	–	–	–	–	–	–	–	20.56	26.00
Ground South Carolina phosphate,	.85	–	–	–	2.94	25.84	28.78	26.56	2.94	–	–	–

TABLE B. — *Compilation of Analyses of Commercial Fertilizers, Special Crop Brands, for the Year 1905 (Per Cent.).*

NAME OF FERTILIZER.	Moisture.	NITROGEN IN ONE HUNDRED POUNDS.			TOTAL PHOSPHORIC ACID IN ONE HUNDRED POUNDS.			AVAILABLE PHOSPHORIC ACID IN ONE HUNDRED POUNDS.			POTASSIUM OXIDE IN ONE HUNDRED POUNDS.		
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
Corn fertilizer,	11.11	3.87	1.02	2.03	16.24	8.32	11.17	12.92	4.70	8.58	12.27	1.74	4.06
Fruit and vine fertilizer,	11.69	3.00	2.16	2.48	10.88	7.60	9.39	9.78	4.68	7.32	11.68	6.20	8.08
Grass fertilizer,	7.57	8.86	1.33	4.19	16.24	4.76	8.94	10.74	2.58	6.54	12.27	1.74	5.72
Market-garden fertilizer,	9.97	4.85	1.84	3.19	13.22	5.04	9.93	10.74	2.58	7.59	12.50	2.02	6.51
Onion fertilizer,	11.11	3.87	1.02	2.03	16.24	8.32	11.17	12.92	4.70	8.58	12.27	1.74	4.06
Potato fertilizer,	10.77	4.98	1.02	2.59	15.00	6.02	10.45	9.86	5.08	8.07	10.18	2.20	5.67
Tobacco fertilizer,	10.70	5.77	.53	3.33	13.30	5.86	10.05	11.10	1.60	7.34	14.84	2.20	7.38
Root crop fertilizer,	8.14	3.76	3.01	3.31	12.06	9.98	10.64	9.66	7.72	8.59	10.04	7.04	8.05

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State during the Past Year (May 1, 1905, to May 1, 1906), and the Brands licensed by Each.

The American Agricultural Chemical Co., Boston, Mass.: —
- High-grade Fertilizer with Ten Per Cent. Potash.
- Grass and Lawn Top Dressing.
- Tobacco Starter and Grower.
- Fine-ground Bone.
- Dissolved Bone-black.
- Muriate of Potash.
- Double Manure Salt.
- High-grade Sulfate of Potash.
- Nitrate of Soda.
- Dry Ground Fish.
- Plain Superphosphate.
- Sulfate of Ammonia.
- Kainit.
- Dried Blood.
- Fine-ground Tankage.
- Ground South Carolina Phosphate.

The American Agricultural Chemical Co. (Bradley Fertilizer Co., branch), Boston, Mass.: —
- Bradley's Complete Manure for Potatoes and Vegetables.
- Bradley's Complete Manure for Corn and Grain.
- Bradley's Complete Manure with Ten Per Cent. Potash.
- Bradley's Complete Manure for Top-dressing Grass and Grain.
- Bradley's X L Superphosphate.
- Bradley's Potato Manure.
- Bradley's Potato Fertilizer.
- Bradley's Corn Phosphate.
- Bradley's Eclipse Phosphate.
- Bradley's Niagara Phosphate.
- Bradley's English Lawn Fertilizer.
- Bradley's Columbia Fish and Potash.
- Bradley's Abattoir Bone Dust.
- Church's Fish and Potash.

The American Agricultural Chemical Co. (H. J. Baker & Bro., branch), New York, N. Y.: —
- Baker's A A Ammoniated Superphosphate.
- Baker's Complete Potato Manure.

The American Agricultural Chemical Co. (Clark's Cove Fertilizer Co., branch), Boston, Mass.: —
- Clark's Cove Bay State Fertilizer.
- Clark's Cove Bay State Fertilizer, G. G.
- Clark's Cove Great Planet Manure.
- Clark's Cove Potato Manure.
- Clark's Cove Potato Fertilizer.
- Clark's Cove King Philip Guano.

The American Agricultural Chemical Co. (Crocker Fertilizer and Chemical Co., branch), Buffalo, N. Y.: —
- Crocker's Potato, Hop and Tobacco Phosphate.
- Crocker's Corn Phosphate.

The American Agricultural Chemical Co. (Cumberland Bone Phosphate Co., branch), Boston, Mass.: —
- Cumberland Superphosphate.
- Cumberland Potato Fertilizer.

The American Agricultural Chemical Co. (L. B. Darling Fertilizer Co., branch), Pawtucket, R. I.: —
- Darling's Blood, Bone and Potash.
- Darling's Complete Ten Per Cent. Manure.
- Darling's Potato Manure.
- Darling's Farm Favorite.
- Darling's Potato and Root Crop Manure.
- Darling's General Favorite.

The American Agricultural Chemical Co. (Great Eastern Fertilizer Co., branch), Rutland, Vt.: —
- Great Eastern Garden Special.
- Great Eastern Vegetable, Vine and Tobacco.
- Great Eastern Northern Corn Special.
- Great Eastern General Fertilizer.
- Great Eastern Grass and Oats Fertilizer.

The American Agricultural Chemical Co. (Pacific Guano Co., branch), Boston, Mass.: —
- Pacific High-grade General.
- Pacific Potato Special.
- Soluble Pacific Guano.
- Pacific Nobsque Guano.

The American Agricultural Chemical Co. (Packers' Union Fertilizer Co., branch), Rutland, Vt.: —
- Packers' Union Universal Fertilizer.
- Packers' Union Potato Manure.
- Packers' Union Animal Corn Fertilizer.
- Packers' Union Gardener's Complete Manure.
- Packers' Union Wheat, Oats and Clover Fertilizer.

The American Agricultural Chemical Co. (Quinnipiac Co., branch), Boston, Mass.: —
- Quinnipiac Market-garden Manure.
- Quinnipiac Phosphate.
- Quinnipiac Potato Manure.
- Quinnipiac Potato Phosphate.
- Quinnipiac Corn Manure.
- Quinnipiac Climax Phosphate.
- Quinnipiac Onion Manure.

The American Agricultural Chemical Co. (Read Fertilizer Co., branch), New York, N. Y.: —
- Read's Practical Potato Special.
- Read's Farmers' Friend.
- Read's Standard.
- Read's High-grade Farmers' Friend.
- Read's Vegetable and Vine.

The American Agricultural Chemical Co. (Standard Fertilizer Co., branch), Boston, Mass.: —
- Standard Complete Manure.
- Standard Fertilizer.
- Standard Special for Potatoes.
- Standard Guano.

The American Agricultural Chemical Co. (Henry F. Tucker Co., branch), Boston, Mass.: —
- Tucker's Original Bay State Bone Superphosphate.
- Tucker's Special Potato Fertilizer.

The American Agricultural Chemical Co. (Williams & Clark Fertilizer Co., branch), Boston, Mass.: —
- Williams & Clark's High-grade Special.
- Williams & Clark's Americus Phosphate.
- Williams & Clark's Potato Phosphate.
- Williams & Clark's Potato Manure.
- Williams & Clark's Corn Phosphate.
- Williams & Clark's Royal Bone Phosphate.
- Williams & Clark's Prolific Crop Producer.

The American Agricultural Chemical Co. (M. E. Wheeler & Co., branch), Rutland, Vt.: —
- Wheeler's Bermuda Onion Grower.
- Wheeler's Potato Manure.
- Wheeler's Havana Tobacco Grower.
- Wheeler's Corn Fertilizer.
- Wheeler's Grass and Oats Fertilizer.

W. H. Abbott, Holyoke, Mass.: —
- Abbott's Animal Fertilizer.
- Abbott's Eagle Brand.
- Abbott's Tobacco Fertilizer.

The American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.
- Cotton-seed Hull Ashes.

The American Linseed Co., New York, N. Y.: —
- Cleveland Flax Meal.

Armour Fertilizer Works, Baltimore, Md.: —
- Armour's Grain Grower.
- Armour's Blood, Bone and Potash.
- Armour's High-grade Potato.
- Armour's All Soluble.
- Armour's Ammoniated Bone with Potash.
- Armour's Bone Meal.
- Armour's Complete Potato.
- Armour's Corn King.
- Armour's Market-garden Fertilizer.

H. J. Baker & Bro., New York, N. Y.: —
- Castor Pomace.

Beach Soap Co., Lawrence, Mass.: —
- Beach's Advance Fertilizer.
- Beach's Reliance Fertilizer.

Berkshire Fertilizer Co., Bridgeport, Conn.: —
- Complete Fertilizer.
- Potato and Vegetable Phosphate.
- Ammoniated Bone Phosphate.

Joseph Breck & Sons, Boston, Mass.: —
- Breck's Lawn and Garden Dressing.
- Breck's Market-garden Manure.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures.
- Bowker's Hill and Drill Phosphate.
- Bowker's Farm and Garden Phosphate.
- Bowker's Lawn and Garden Dressing.
- Bowker's Potato and Vegetable Fertilizer.
- Bowker's Fish and Potash (Square Brand).
- Bowker's Potato and Vegetable Phosphate.
- Bowker's Sure Crop Phosphate.
- Gloucester Fish and Potash.
- Bowker's High-grade Fertilizer.
- Bowker's Bone and Wood Ash Fertilizer.
- Bowker's Fish and Potash ("D" Brand).
- Bowker's Corn Phosphate.
- Bowker's Blood, Bone and Potash.
- Bowker's Early Potato Manure.
- Bowker's Bristol Fish and Potash.
- Bowker's Fine-ground Dry Fish.

Bowker Fertilizer Co., Boston, Mass. — *Con.*
- Bowker's Tobacco Ash Elements.
- Bowker's Wood Ashes.
- Bowker's Ground Bone.
- Bowker's Superphosphate.
- Sulfate of Ammonia.
- Nitrate of Soda.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulfate of Potash.
- Dried Blood.
- Bowker's Soluble Animal Fertilizer.
- Bowker's Tobacco Starter.
- Bowker's Tobacco Ash Fertilizer.
- Bowker's Market-garden Fertilizer.
- Bowker's Potash Bone.
- Bowker's Ten Per Cent. Manure.
- Kainit.
- Bowker's Complete Mixture.
- Bowker's Ammoniated Food for Flowers.
- Double Manure Salt.
- Bowker's Tankage.
- Bowker's Clover Brand Bone and Wood Ash.
- Bowker's Flour of Bone.
- Bowker's Market Bone.
- Bowker's Ground Phosphate Rock.
- Bowker's Ammoniated Dissolved Bone.
- Bowker's Square Brand Bone and Potash.
- Bowker's Potash or Staple Phosphate.
- Bowker's Special Fertilizer for Seeding Down.

F. W. Brode & Co., Memphis, Tenn.: —
- Owl Brand Pure Cotton-seed Meal.

T. H. Bunch, Little Rock, Ark.: —
- Cotton-seed Meal.

Charles M. Cox & Co., Boston, Mass.: —
- Cotton-seed Meal.

Chicopee Rendering Co., Springfield, Mass.: —
- Lawn and Garden Dressing
- Vegetable and Potato Fertilizer.

E. Frank Coe Co., New York, N. Y.: —
- E. Frank Coe's High-grade Ammoniated Bone Superphosphate.
- E. Frank Coe's Gold Brand Excelsior Guano.
- E. Frank Coe's Excelsior Potato Fertilizer.
- E. Frank Coe's Tobacco and Onion Fertilizer.
- E. Frank Coe's Columbian Corn Fertilizer.

E. Frank Coe Co., New York, N. Y.— *Con.*
- E. Frank Coe's Columbian Potato Fertilizer.
- E. Frank Coe's New Englander Potato Fertilizer.
- E. Frank Coe's New Englander Corn Fertilizer.
- E. Frank Coe's X X X Pure Ground Bone.
- E. Frank Coe's F. P. Fish and Potash.
- E. Frank Coe's Red Brand Excelsior Guano.
- E. Frank Coe's Celebrated Special Potato.
- E. Frank Coe's Grass and Grain Special.
- E. Frank Coe's X X X Ammoniated Bone Phosphate.
- E. Frank Coe's Muriate of Potash.
- E. Frank Coe's Nitrate of Soda.

John C. Dow & Co., Boston, Mass.: —
- Dow's Pure Ground Bone.

The Eureka Liquid Fertilizer Co., Boston, Mass.: —
- Eureka Liquid Fertilizer.

William E. Fyfe & Co., Clinton, Mass.: —
- Hard Wood Canada Ashes.

R. & J. Farquhar & Co., Boston, Mass.: —
- Clay's London Fertilizer.

C. W. Hastings, Ashmont, Mass.: —
- Ferti Flora.

Thomas Hersom & Co., New Bedford, Mass.: —
- Bone Meal.
- Meat and Bone.

Hunter Brothers Milling Co., St. Louis, Mo.: —
- Prime Cotton-seed Meal.

John Joynt, Lucknow, Ont., Can.: —
- Joynt Brand Hard-wood Ashes.

A. Klipstein & Co., New York, N. Y.: —
- Carbonate of Potash.

Lister's Agricultural Chemical Works, Newark, N. J.: —
- Lister's Success Fertilizer.
- Lister's Special Corn Fertilizer.
- Lister's Special Potato Fertilizer.
- Lister's Potato Manure.
- Lister's High-grade Special for Spring Crops.
- Lister's Oneida Special.
- Lister's Animal Bone and Potash.

Swift's Lowell Fertilizer Co., Boston, Mass.: —
- Swift's Lowell Bone Fertilizer.
- Swift's Lowell Potato Phosphate.
- Swift's Lowell Dissolved Bone and Potash.
- Swift's Lowell Animal Brand.
- Swift's Lowell Market-garden Manure.
- Swift's Lowell Potato Manure.
- Swift's Lowell Empress Brand.
- Swift's Lowell Superior Fertilizer.
- Swift's Lowell Special Grass Mixture.
- Swift's Lowell Lawn Dressing.
- Swift's Lowell Perfect Tobacco Grower.
- Swift's Lowell Ground Bone.
- Swift's Lowell Special Vegetable Manure.
- Acid Phosphate.
- Nitrate of Soda.
- Muriate of Potash.
- Tankage.

George E. Marsh & Co., Lynn, Mass.: —
- Pure Bone Meal.

D. M. Moulton, Monson, Mass.: —
- Ground Bone.

Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
- Mapes' Potato Manure.
- Mapes' Tobacco Starter Improved.
- Mapes' Tobacco Manure (Wrapper Brand).
- Mapes' Economical Potato Manure.
- Mapes' Average Soil Complete Manure.
- Mapes' Vegetable Manure or Complete Manure for Light Soils.
- Mapes' Corn Manure.
- Mapes' Complete Manure ("A" Brand).
- Mapes' Cereal Brand.
- Mapes' Complete Manure Ten Per Cent. Potash.
- Mapes' Top-dresser Improved, Half Strength.
- Mapes' Tobacco Ash Constituents.
- Mapes' Grass and Grain Spring Top-dressing.
- Mapes' Fruit and Vine Manure.
- Mapes' Cauliflower and Cabbage Manure.

National Fertilizer Co., Bridgeport, Conn.: —
- Chittenden's Complete Fertilizer.
- Chittenden's High-grade Special Tobacco.
- Chittenden's Market Garden.
- Chittenden's Potato Phosphate.

National Fertilizer Co., Bridgeport, Conn. — *Con.*
- Chittenden's Ammoniated Bone.
- Chittenden's Fish and Potash.
- Chittenden's X X X Fish and Potash.
- Chittenden's Formula "A."

New England Fertilizer Co., Boston, Mass.: —
- New England Corn Phosphate.
- New England Potato Fertilizer.
- New England Superphosphate.
- New England High-grade Potato Fertilizer.

Olds & Whipple, Hartford, Conn.: —
- Complete Tobacco Fertilizer.
- Vegetable Potash.

R. T. Prentiss, Holyoke, Mass.: —
- Prentiss Complete Fertilizers.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
- Plymouth Rock Brand.
- Special Fertilizer for Strawberries.
- Special Potato Fertilizer.
- Nitrate of Soda.
- A. A. Brand Fertilizer.
- P. & P. Potato Fertilizer.
- Pure Ground Bone.
- Lawn Dressing.
- P. & P. Grain Grower.
- Star Brand Superphosphate.

Rogers & Hubbard Co., Middletown, Conn.: —
- Hubbard's Oats and Top-dressing.
- Hubbard's Grass and Grain.
- Hubbard's Soluble Corn.
- Hubbard's Soluble Potato.
- Hubbard's Soluble Tobacco.
- Hubbard's All Soils and All Crops.
- Hubbard's Corn Phosphate.
- Hubbard's Potato Phosphate.
- Hubbard's Market-garden Phosphate.
- Hubbard's Raw Knuckle Bone Flour.
- Hubbard's Strictly Pure Fine Bone.

Rogers Manufacturing Co., Rockfall, Conn.: —
- All Round Fertilizer.
- Complete Potato and Vegetable Fertilizer.
- High-grade Complete Corn and Onion.
- Fish and Potash.
- High-grade Tobacco and Potato.
- High-grade Oats and Top-dressing.
- High-grade Grass and Grain.
- High-grade Soluble Tobacco.
- Pure Knuckle Bone.

Ross Bros., Worcester, Mass.: —
- Ross Brothers' Lawn Dressing.

N. Roy & Son, South Attleborough, Mass.: —
Complete Animal Fertilizer.

Russia Cement Co., Gloucester, Mass.: —
Essex Dry Ground Fish.
Essex Complete Manure for Potatoes, Roots and Vegetables.
Essex Complete Manure for Corn, Grain and Grass.
Essex Market-garden and Potato Manure
Essex Corn Fertilizer.
Essex A I Superphosphate.
Essex X X X Fish and Potash.
Essex Odorless Lawn Dressing.
Essex Tobacco Starter.
Essex Special Tobacco Manure.
Essex Rhode Island Special.
Essex Grass and Top-dressing.
Essex Nitrate of Soda.

Sanderson's Fertilizer and Chemical Co., New Haven, Conn.: —
Sanderson's Formula "A".
Sanderson's Formula "B".
Sanderson's Potato Manure.
Sanderson's Corn Superphosphate.
Sanderson's Fine-ground Fish.
Sanderson's Sulfate of Potash.
Walker's Complete Phosphate.
Walker's Complete Fertilizer.
Walker's High-grade Fertilizer.
Niantic Bone, Fish and Potash.
Old Reliable Superphosphate.

The Smith Agricultural Chemical Co., Columbus, O. (Abbott & Martin Rendering Co., branch): —
Harvest King.
Tobacco and Potato Special.

The Smith Agricultural Chemical Co., Columbus, O. (Hardy Packing Co., branch): —
Tankage Bone and Potash.
Tobacco and Potato Special.

M. L. Shoemaker & Co., Limited, Philadelphia, Pa.: —
Swift Sure Superphosphate.
Swift Sure Bone Meal.

Thomas L. Stetson, Randolph, Mass.: —
Bone Meal.

A. L. Warren, Northborough, Mass.: —
Warren's Ground Bone.

The Whitman & Pratt Rendering Co., Lowell, Mass.: —
Whitman & Pratt's All Crops.
Whitman & Pratt's Corn Success.
Whitman & Pratt's Vegetable Grower.
Whitman & Pratt's Potash Special.
Whitman & Pratt's Pure Ground Bone.
Whitman & Pratt's Potato Plowman.

Wilcox Fertilizer Works, Mystic, Conn.: —
Wilcox Potato, Onion and Tobacco Manure.
Wilcox Potato Fertilizer.
Wilcox Complete Bone Superphosphate.
Wilcox Fish and Potash.
Wilcox High-grade Tobacco Special.
Wilcox Dry Ground Fish.

Sanford Winter, Brockton, Mass.: —
Pure Fine-ground Bone.

J. M. Woodward & Bro., Greenfield, Mass.: —
Tankage.

PART II. — REPORT ON GENERAL WORK IN THE CHEMICAL LABORATORY.

C. A. GOESSMANN.

1. Analyses of materials forwarded for examination.
2. Notes on wood ashes and lime ashes.

1. ANALYSES OF MATERIALS FORWARDED FOR EXAMINATION.

We have received 257 samples of miscellaneous substances, during the season, from farmers within our State. As far as circumstances and time permit we have taken up these materials for analysis, and as a general thing have reported results in the order of their arrival at this office. As in the past, we have been obliged to neglect this class of work until a lull occurred in the official inspection of commercial fertilizers. From December to April we have most time to devote to the investigation of general material, and for this reason would prefer to have the samples forwarded whenever possible, so they may be taken up during these months. This would insure more prompt reports of the results of analyses.

We have taken the usual active part in the technical chemical work of the Association of Official Agricultural Chemists for the establishment of new methods of chemical analysis, more particularly in regard to fertilizer work and the analysis of insecticides. We have also been in co-operation with the American Chemical Society and the United States Geological Survey in regard to technical details in the chemical analysis of argillaceous limestone. The results of these analyses were sent to the respective parties in Washington.

Following is a list of materials forwarded by farmers during the year: —

Soils,	54
Wood ashes,	47
Complete fertilizers,	32
Cotton-seed meal,	24
Lime ashes,	8
Miscellaneous materials,	7
Nitrate of soda,	6
Manure,	6
Muck,	5
Tankage,	4
Superphosphate,	4
Cotton-hull ashes,	4
High-grade sulfate of potash,	3
Ground bone,	3
Bone and meat,	3
Sheep manure,	3
Peruvian guano,	3
Peat,	3
Dry ground fish,	2
Dissolved bone-black,	2
Wood charcoal,	2
Muriate of potash,	2
Carbonate of potash,	2
Factory waste,	2
Ashes from leather scraps,	2
Insecticides,	2
Oyster shells,	1
Sulfate of ammonia,	1
Blood,	1
Wool waste ashes,	1
Chicken grit,	1
Tobacco dust,	1
Argillaceous limestone,	1
Burned bone,	1
Low-grade sulfate of potash,	1
River mud,	1
Cob ashes,	1
Castor pomace,	1
Linseed meal,	1
Mud from seaweed,	1
Cotton-seed compost,	1
Damaged cocoa,	1
Prepared bone,	1
Vegetable potash,	1
Rotten cotton waste,	1

2. NOTES ON WOOD ASHES AND LIME ASHES.

(*a*) *Wood Ashes.*

Eighteen and one-half per cent. of the materials forwarded by farmers during the year have been wood ashes. The following table shows their chemical composition as compared with the previous year: —

Analysis of Wood Ashes.

	NUMBER OF SAMPLES.	
	1904.	**1905.**
Moisture from 1 to 10 per cent.,	18	15
Moisture from 10 to 20 per cent.,	16	20
Moisture from 20 to 30 per cent.,	8	7
Moisture above 30 per cent.,	3	1
Potassium oxide above 8 per cent.,	2	4
Potassium oxide from 6 to 7 per cent.,	8	4
Potassium oxide from 5 to 6 per cent.,	6	12
Potassium oxide from 4 to 5 per cent.,	12	13
Potassium oxide from 3 to 4 per cent.,	10	7
Potassium oxide below 3 per cent.,	7	3
Phosphoric acid above 2 per cent.,	3	7
Phosphoric acid from 1 to 2 per cent.,	30	32
Phosphoric acid below 1 per cent.,	12	4
Average per cent. of calcium oxide (lime),	30.16	32.30
Insoluble matter below 10 per cent.,	6	9
Insoluble matter from 10 to 15 per cent.,	18	14
Insoluble matter above 15 per cent,	20	20

Table showing the Maximum, Minimum and Average Per Cents. of the Different Ingredients found in Wood Ashes, 1904 and 1905.

	MAXIMUM.		MINIMUM.		AVERAGE.	
	1904.	**1905.**	**1904.**	**1905.**	**1904.**	**1905.**
Moisture at 100° C.,	37.85	32.05	none.	.02	14.42	13.45
Potassium oxide,	11.04	8.68	.80	2.32	4.51	5.09
Phosphoric acid,	6.07	4.74	.28	.38	1.37	1.67
Calcium oxide,	42.86	49.24	19.73	21.17	30.16	32.30
Insoluble matter,	47.21	33.32	4.56	4.15	18.35	15.49

From the above comparison it will be seen that the ashes analyzed during the year are of much better quality than for the year 1904. We wish to urge parties who buy wood ashes to patronize those importers and dealers who have secured a license for the sale of ashes in Massachusetts, for it is only in this way that they can secure protection by our State laws. Wood ashes should always be bought on a statement of guarantee of potash, phosphoric acid and lime.

(b) *Lime Ashes.*

Table showing the Maximum, Minimum and Average Per Cents. of the Different Ingredients found in Lime Ashes, 1904 and 1905.

	MAXIMUM.		MINIMUM.		AVERAGE.	
	1904.	**1905.**	**1904.**	**1905.**	**1904.**	**1905.**
Moisture,	36.62	19.35	none.	.05	10.88	11.18
Potassium oxide,	2.46	4.80	.06	1.02	1.54	2.47
Phosphoric acid,	1.48	1.58	trace.	.18	.74	.97
Calcium oxide,	55.24	63.44	21.92	37.56	42.93	49.34
Insoluble matter,	25.47	28.93	2.76	3.21	8.11	8.99

It will be seen from the above comparison that the average composition of lime ashes for the past year is superior to that of 1904. The only safe way to buy lime ashes is to insist upon a guarantee of potash, phosphoric acid and lime which they are said to contain.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.[1]

J. B. LINDSEY.

Chemical Assistants: E. B. HOLLAND, P. H. SMITH, E. S. FULTON,[2] A. C. WHITTIER.
Inspector of Feeds and Babcock Machines: A. PARSONS,[3] F. G. HELYAR.
Dairy Tester: S. R. PARKER.
In Charge of Feeding Experiments: J. G. COOK,[4] R. F. GASKILL.
Stenographer: MABEL C. SMITH.

PART I. — THE WORK OF THE YEAR.

1. Correspondence.
2. Summary of laboratory work.
3. Water analysis.
4. Dairy products and cattle feeds.
5. Special chemical work.
6. Feed control.
7. Act for protection of dairymen.
8. The testing of pure-bred cows.
9. Work completed.
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11. Changes in staff.

PART II. — EXPERIMENTS IN ANIMAL NUTRITION.

1. Bibby's dairy cake.
2. Eureka silage corn.
3. Concerning wheat bran.

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[1] See also tables in Appendix.
[2] Resigned Sept. 15, 1905.
[3] Resigned July 1, 1905.
[4] Resigned Aug. 1, 1905.

PART I. — THE WORK OF THE YEAR.

J. B. LINDSEY.

1. CORRESPONDENCE.

The answering of inquiries relative to feeding and dairy problems has continued to be a feature of the correspondence of this department. Grain dealers appear desirous of being well posted on the various feed stuffs in the market, and are constantly writing for information. The total number of letters of all kinds sent out during the year was approximately 3,600.

2. SUMMARY OF LABORATORY WORK.

The usual variety of chemical work has been carried out during the year.

There have been sent in for examination 102 samples of water, 792 of milk, 1,717 of cream, 5 of butter, 191 of feed stuffs and 6 miscellaneous. In connection with experiments by this and other divisions of the station, there have been analyzed, in whole or in part, 236 samples of milk and cream and 142 of fodders and feed stuffs. This makes a total of 4,042 substances analyzed during the year, as against 4,261 last year and 3,897 in the previous year. Work on the determination of sulphur in organic bodies, and nitrogen compounds in cheese, not included in the above, has been done for the Association of Official Agricultural Chemists. In addition, 13 candidates have been examined and given certificates to operate Babcock machines, and 1,665 pieces of glassware have been tested for accuracy, of which 197 pieces, or 11.83 per cent., were condemned.

3. WATER ANALYSIS.

The experiment station has made a feature of sanitary water analysis since its establishment in 1882. Within a few years a charge of $3 a sample has been placed upon this work, in order to hold in check many who have seemingly abused the privilege of free analysis. Instructions for securing an analysis are issued in circular form, as follows: —

> Those wishing to secure a sanitary analysis of water must first make application, whereupon a glass bottle securely encased, accompanied by full instructions for collecting and shipping the sample, will be forwarded by express. The return express must in all cases be prepaid. Because of the smallness of the sum involved, no account will be opened. Remittance by check, P. O. money order, or money at the owner's risk, must be strictly in advance.
>
> Address Dr. J. B. Lindsey,
> *Hatch Experiment Station, Amherst, Mass.*

The results of the analysis are forwarded on especially prepared blanks, with such additional remarks concerning the condition of the water, and its possible improvement, as is warranted in each case. This station does not make mineral analysis of water, excepting at rare intervals by special arrangement.

4. Dairy Products and Cattle Feeds.

This department makes free analyses of milk, cream and cattle feeds for farmers and others, in so far as its resources permit. About the usual number have been received during the year. Many farmers and dairymen desire to know the percentage of fat and total solids in the milk produced by their herd and by individual animals, and send samples to the station for analysis. They are thus enabled to determine the quality of the product placed upon the market, and also the value of the cow for profitable milk production. The quality of the milk shipped to Boston is carefully scrutinized by the several contractors, and producers frequently send samples to the station, to ascertain whether their product is conforming to the legal requirements. Parties who have been warned by the contractors, or have had their milk refused, likewise forward samples, with requests for information as to methods of betterment. The station tries to be as helpful as possible in all such cases. One creamery sends its samples regularly, and others send occasional lots, when not in condition to satisfactorily perform the work, or when desiring to check their own results. A charge is made in such cases sufficient to cover the cost of the work.

Farmers and grain dealers are constantly sending samples of feeds for examination, to determine their value and whether they are as represented. This work takes considerable time, but it is worthy of encouragement. It must not be understood, however, that the station furnishes a free chemical laboratory for jobbers and manufacturers who wish to ascertain the composition of their feeds for commercial purposes. The station does not solicit work of this character, but is willing to undertake a limited amount for a reasonable compensation.

5. Special Chemical Work.

During the year the department has undertaken co-operative work on chemical methods in connection with the Association of Official Agricultural Chemists, and has studied particularly methods for the determination of sulphur in organic substances, and of nitrogenous compounds in cheese. The department has also co-operated with the department of botany in ascertaining the amount of starch and sugars in cucumber leaves, grown under definite conditions.

6. Feed Control (Acts of 1903, Chapter 202).

The several provisions of this act have been executed as heretofore. Bulletin No. 101, containing the analyses of 306 samples of feeds collected the previous autumn, was distributed early in January of 1905. This bulletin also contained many remarks and suggestions on the nutritive and commercial values of concentrates. Bulletin No. 106, sent out in October, 1905, gave the chemical and microscopic analyses of 65 samples of condimental stock and poultry foods, and the results of an experiment with Pratt's food. During the months of January, February, March and April, the inspector twice visited the most important cities and towns in the State, and collected 481 samples of feeds. The entire collection was tested during the late spring and early summer. For financial reasons, it was not possible to publish the results in bulletin form. Those that were considered at all suspicious were examined by both the chemist and the microscopist, and the attention of retail dealers, jobbers and manufacturers called to any irregularities. Brief notes regarding this collection were published in Bulletin No. 106. The inspector canvassed the entire State in September and October, and the 365 samples collected are now being examined, and the results will be ready for publication in December. •

The large majority of manufacturers, jobbers and retailers willingly conform to the requirements of the law. Considerable difficulty is frequently experienced in obtaining a statement in full, many omitting the weight of the package, and a few stating the protein and fat guarantees together. Some manufacturers and jobbers have been lax in attaching any guarantee whatever, and retailers have frequently offered unguaranteed goods for sale. The station has endeavored to be very patient with offenders, giving them full opportunity to conform to the statute requirements. The writer recognizes the diversity of conditions governing the purchase and sale of the great variety of concentrated feeds, and has been willing to condone many technical violations of the law, when it appeared that no intentional offence was intended. Some parties seem inclined to take advantage of this seeming leniency, and such it may be necessary to call to a sharp account.

The value of an intelligent and tactful inspector cannot be too strongly emphasized. He is in position to impart much valuable information to the dealer, and to smooth out many difficulties that may arise. The station finds it difficult to retain the services of a satisfactory person for any length of time, because of the small salary paid.

The great bulk of feed now offered is free from intentional adulteration, and is as represented. Buyers, as a rule, have only themselves to blame if they are defrauded. Much cotton-seed meal is being guaranteed several per cent. lower in protein than formerly, manufacturers claiming that it does not pay them to completely remove the hulls. It is also stated that this lower-grade meal is shipped from other territory than that formerly supplying the Massachusetts markets.

Gluten feed and wheat by-products tested low in protein during 1905, owing to the inferior character of the 1904 corn and wheat.

Porto Rico molasses and a considerable variety of molasses feeds are being freely offered. The station is making a special study of these products, and hopes to publish the results in bulletin form within the next few months.

Rice by-products in considerable quantity are being sold in the southwest, but as yet they have not been offered in local markets. Detailed information concerning the composition and value of concentrates may be obtained by consulting the special bulletins on the subject.

7. AN ACT FOR THE PROTECTION OF DAIRYMEN (ACTS OF 1901, CHAPTER 202).

This act makes it obligatory for all creameries and milk depots within the State, employing the Babcock test or any other test for determining the value of milk or cream, to have all graduated glassware used in making such determinations tested for accuracy by this station. It further requires that all parties intending to operate such machines must first be examined for competency by the proper official of the station. Once each year the station is obliged to send a competent party to each creamery and milk depot within the State where such machines are in use, to duly inspect said machines and pronounce upon their fitness for the work. This department has endeavored to carry out the several provisions of this law with the same care as formerly. The following is a brief report of the work for 1905: —

Inspection of Glassware. — All glassware found to be correctly graduated has been marked "Mass Ex St." There were 1,665 pieces examined, of which 197, or 11.83 per cent., were condemned. The inaccurate bottles were largely of the bulb type (Bartlett). Until last year these bottles have been passed on accuracy of total graduation, as the usual charge of 5 cents a piece would not permit of additional testing. Because of the difficulty in securing a correct graduation, it has been necessary to test the three distinct portions of the scale at a corresponding increase in cost. The use of this type of bottle is not to be encouraged.

Examination of Candidates. — A few less candidates than usual were examined, and 13 certificates of competency issued. Many candidates showed poor manipulation, and lacked a thorough understanding of the method. In case of failure, applicants are obliged to wait a month before a second examination will be given.

Inspection of Babcock Machines. — The inspection of machines the present year has been in charge of Mr. Frank G. Helyar, who makes the following report: —

The annual inspection of Babcock machines was made in November and December. Fifty-two places were either visited or heard from, of which number only 36 were amenable to the inspection. Those creameries or milk depots that did not come under the inspection were exempt for two reasons: some of them do not possess a machine, but have their samples regularly tested by city inspectors; while others have machines, but from all that can be learned they neither buy nor sell milk or cream on the results of their own tests. In suspicious cases they carry samples to the city inspector. There are three creameries paying by the space and one by the churn test.

Of the total number, 34 were creameries and 18 were milk depots. Of the 34 creameries, 19 were situated west of the Connecticut River, and, as a rule, in the back-hill towns, away from good transportation facilities. The rest of the creameries were scattered throughout the eastern part of the State. The milk depots, on the other hand, are situated nearer the large cities. Twenty of the milk depots and creameries were co-operative, while the rest were either proprietary or stock companies. The number of co-operative creameries is steadily decreasing.

As a whole, the machines were found to be in very good condition, none being condemned, and only 3 needing repairs. The cast-iron machine is being used in every place visited but 4. The Facile is used in 19 places, the Agos in 9 and the Wizard in 3.

Most of the owners of the Babcock machines have recognized the value of a substantial foundation as a factor in keeping their machines in good repair. Still, there are a few machines that are being used on rather insecure and shaky supports. As a result, these machines are always a little out of level, and run with more or less unnecessary vibration. Some machines, even with repairs suggested in previous inspections, still overheat the samples. The operators of these machines counteract this by allowing the machine to run a few moments at the end of the test with the cover lifted. No machine was found that insufficiently heated the samples. The steam gauges, with only one or two exceptions, were found to be in good order. In those cases where they were not in good order, speed indicators are used to check up the speed of the machines.

Only in one place was untested glassware found. In some cases it was not as clean as it ought to be, but, on the whole, may be said to be in very good condition.

In addition to the regular work of the inspection, 4 city milk inspectors were visited. Only 1 desired an examination. His machine, an electrical Wizard, was given a certificate.

The above law is not as comprehensive as one could wish. It makes no financial provision for the purpose of carrying out the provisions of section 3 (inspection of machines), but requires the director of the station, or his agent, to make the inspection, and to assess the cost upon the several creameries inspected. The station is obliged to advance the expense out of its treasury, and collect 35 or 40 small bills resulting. Most creameries pay with a reasonable degree of promptness, but a few parties are obstinate and slow.

After the station has issued a certificate of competency to the operator of a Babcock machine, it has no further control over said party, even though he may prove careless, and even dishonest in his future operations. The law could be improved, and thus give a fuller measure of protection to dairymen, by a small annual State appropriation, together with the necessary authority to make a semi-annual inspection of all Babcock or similar machines, and of all glassware used in connection therewith, and by empowering the director of the experiment station, or some other competent party, to rescind the license of all operators who do not appear to be satisfactorily performing their duties.

8. The Testing of Pure-bred Cows.

Breeders of pure-bred Jersey, Guernsey and Holstein cattle are making tests of the weekly and yearly yields of milk and butter fat produced by their cows, under the rules and regulations of the several national cattle clubs. The rules require that these tests be made under the strict supervision of an officer of the Agricultural College or Experiment Station. This department has undertaken the work for Massachusetts breeders. Considerable more testing has been required during 1905 than heretofore, necessitating the temporary employment of 5 different inspectors at one time. It is frequently quite difficult and time-consuming for the regular employees to be required to meet the sudden demands of breeders for men to do work of this character, although thus far all calls for men and apparatus have been met promptly. Breeders ought to give the station at least ten days' notice. The cost of this work is paid by the parties for whom it is done, and includes tester's time at $2 to $2.50 a day, board, travelling expenses and breakage. There are at present 44 Jerseys and 29 Guernseys under yearly tests, belonging to F. L. Ames, North Easton, N. I. Bowditch, Framingham, W. L. Cutting, Pittsfield, C. H. Jones, Wellesley Farms, A. H. Sagendorph, Spencer, Storrs Agricultural College, Storrs, Conn., C. I. Hood, Lowell, A. F. Pierce, Winchester, N. H., and R. A. Sibley, Spencer. Eight seven-day milk and butter fat tests have been made for the Jersey Cattle Club, and 37 for the Holstein-Friesian Association, and the yearly tests of 32 Jerseys and 12 Guernseys have been completed.

9. Work completed.

Eureka Silage Corn. — A two-years experiment, to study the composition, digestibility and economic value of this corn, a coarse southern dent, as compared with a medium dent that will mature its seed in our latitude, has been completed, and the details and conclusions reported in Part II. of the present report.

The Value of Wheat Bran. — The results of a study of the cost of digestible protein and total digestible matter in wheat bran, as well as the use of bran in the farm economy, are presented quite fully in Part II.

Bibby's Dairy Cake. — Digestion tests and an experiment with dairy cows have been completed with this feed. The details of the experiment, and the conclusions, will be found as a portion of Part II.

Market Milk, its Production and Composition. — This department has investigated the conditions governing the production of milk in the territory supplying Amherst and Northampton, as well as the chemical and bacteriological composition of the milk. It is believed that the methods of production and the quality of the product are much the same as in other sections of the State. In general, it may be said that: —

1. The sanitary conditions on the whole were unsatisfactory.
2. The majority of producers were not familiar with, or did not apply, the teachings of modern dairy principles.
3. The chemical composition of most of the milk was above the Massachusetts standard.
4. A great deal of the milk contains an excess of bacteria, and indicated unsanitary methods of handling.
5. The milk was practically all retailed at 6 cents a quart, — a price too low to enable the producer to profitably produce an article under satisfactory sanitary conditions.

It is believed that producers supplying milk for human consumption should be subject to a system of regular, competent inspection, and that no one should receive a license who does not conform to reasonable sanitary conditions. The public needs to be educated relative to the great food value of milk, and ought to be willing to pay a fair price for an approved article. It is hoped to soon publish the detailed results of this investigation in bulletin form.

Digestion Experiments with Sheep. — There have been completed digestion experiments with soy bean fodder, Eureka corn fodder and Eureka corn stover, Pride of the North corn stover, Blomo feed for horses, malt sprouts, Sucrene, Holstein and Macon sugar feeds, hominy feed, buckwheat and oat middlings. The results have been incorporated in the tables of digestion coefficients, in the Appendix. The details of these experiments and a discussion of the results are reserved for a future publication.

Sorghum and Other Forage Crops. — Trials of a variety of green crops for summer soiling are conducted each year. Sorghum has been given particular attention for the last two years. A very complete analysis of this crop has been made at different stages of growth, and, likewise, digestion trials with sheep, the results of which are not as yet completed. The seed[1] was sown broadcast at the rate of 1 bushel per acre, the 25th of May. Cutting was begun as soon as the heads appeared (about August 10), and the yield was at the rate of 19 tons to the acre. The animals ate it well, and it should prove a satisfactory addition to the list of green feeds. A more detailed statement concerning the quality and value of this crop for soiling will be given in a future publication.

The station has found the following crops quite satisfactory for soiling purposes: peas and oats, the first seeding to be made April 25 and each ten days thereafter, ready to cut from June 25 to July 20; barnyard millet, first seeding to be made May 25 and another seeding two weeks later, ready for feeding from July 20 to August 10; sorghum to be seeded May 25, ready to cut August 10 to 30; Stowell's Evergreen sweet corn, or Longfellow field corn, seeded May 15 to 20, will serve admirably for September green fodder, and later if frosts are not severe.

Soy beans may be sown with the corn, but it is believed that, on the whole, more satisfactory results can be obtained by cultivating each crop separately. It is hoped to publish a bulletin on the subject of soiling in the near future. Copies of a former bulletin on this subject (No. 72) are not available.

Useful Legumes. — A study has been made of the composition, digestibility and yields of the more prominent leguminous crops, with a view to determine their practical adaptability to New England conditions, and it is desired to publish a concise description of this work in the near future.

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[1] Seed purchased of Wm. Henry Maule, Philadelphia, Pa., at $2.25 a bushel.

Clover is unquestionably the most valuable legume, serving admirably as a soil renovator, cover crop, soiling crop, and as a component of the hay crop. Canada peas are valuable chiefly for soiling purposes, and in some cases as a cover crop. Sand vetch (*Vicia sativa*) makes a good legume to be sown in the autumn with wheat for early summer soiling. It also serves as a soil renovator and as a cover crop. Shammel, in Bulletin No. 149 of the Connecticut Experiment Station, has called attention to the value of this plant when sown after the removal of tobacco. It blossoms about June 1, and can then be plowed under, adding materially to the humus and nitrogen content of the soil. It seeds poorly, and the seed is very expensive, which will naturally much restrict its use. Alfalfa has been tried repeatedly on the station ground under favorable conditions, but it has not as yet proved a satisfactory crop for practical purposes. It is affected with "leaf-spot," winter-kills, and is crowded out by clover and grasses. Occasionally one hears of successes by Massachusetts farmers. It is suggested that our farmers try it in a small way (¼ acre), and see if it will thrive in their locality. Soy beans (Brooks's medium green) and several varieties of cow peas have been carefully studied; the latter are best suited to a more southern climate. The soy beans thrive well in Massachusetts, and may be used with satisfaction as a soiling crop, and mixed with corn for silage purposes. It is believed, however, that it will prove more economical, as a rule, for farmers and dairymen possessing satisfactory markets and railroad facilities to purchase their protein in the form of high-grade concentrates, rather than attempt to grow it in the form of soy bean forage or seed. Soy beans may prove an economical crop for localities situated at some distance from markets and railroads.

Compilation of Analyses. — Attention is called to the tables of composition and digestion of American feed stuffs, recently compiled, and published in the Appendix to this report.

10. Work in Progress.

Molasses and Molasses Feeds. — Work is in progress to determine the digestibility and comparative value and place in the farm economy of Porto Rico molasses and molasses feeds. Feeds of this character are being freely advertised and sold in our local markets. It is hoped to bring this work to a close early in the new year, and to report the results in bulletin form within a short time thereafter.

Nitro-cultures for Legumes. — The United States Department of Agriculture has called attention to the value of the cultures produced by its expert, Dr. Moore, for the different leguminous crops. Hellriegel of Germany was the first to scientifically demonstrate the symbiotic action of bacteria with the legumes, resulting in the fixation of atmospheric nitrogen. This subject has been given a great deal of study by many other scientists, particularly by Nobbe and his co-workers, who have isolated and prepared cultures suited to the different varieties of legumes. Moore claims that he has succeeded in isolating and developing varieties of bacteria that are especially active as nitrogen gatherers. This department has secured the Moore cultures for two years, and used them upon alfalfa, soy beans and cow peas. The directions were carefully followed in all cases, but no particular results were obtained that could be attributed directly to the action of the applied cultures. The yields for the soy bean and cow pea plots receiving the cultures were no greater than those not receiving them, neither did the plots thus treated show any noticeable increased nodular development. A newly seeded piece of alfalfa, inoculated with soil from an old alfalfa field, seemed to receive a decided help from the treatment, judging from the growth and apparent vigor of the plants. The writer would in no way condemn the Moore cultures, knowing the progress that has been achieved by numerous investigators along this line. Farmers may try the Moore cultures in a small way, but should not be disappointed if the results are not as expected. The daily press and popular journals have made altogether too extravagant statements and claims regarding them. Work of this character still requires much study before the highest practical results are secured.

11. Changes in Staff.

Albert Parsons, B.S., for two years employed as inspector of concentrated feeds and of Babcock machines, resigned July 1, to accept a position as assistant superintendent at Hood Farm, Lowell, Mass. His place has been filled by the appointment of Frank G. Helyar, B.S., University of Vermont, 1905. Joseph G. Cook, B.S., assistant in animal nutrition, resigned August 1, to become superintendent of the farm at Norfolk, Mass., belonging to T. D. Cook & Co. Roy F. Gaskill, a recent graduate of the Massachusetts Agricultural College dairy course, succeeds him. E. S. Fulton, B.S., assistant chemist, severed his connection with this department September 15, having received an appointment with Dr. F. G. Benedict of Wesleyan University of Middletown, Conn., who has charge of the nutrition investigations for the United States Department of Agriculture. Mr. A. C. Whittier, B.S., University of Maine, 1905, has taken Mr. Fulton's place. The writer desires to express his highest appreciation of the faithfulness, interest and care exercised by all his co-workers in the prosecution of the various lines of work undertaken by this department during the past year.

PART II. — EXPERIMENTS IN ANIMAL NUTRITION.

1. BIBBY'S DAIRY CAKE.

J. B. LINDSEY.[1]

Nature and Composition of the Cake.

This material is made by J. Bibby & Sons, Liverpool, Eng., and is imported in the form of cake. It is composed chiefly of ground cotton-seed, together with locust or carob bean,[2] cereals (maize, wheat, etc.) or their by-products, fenugreek and salt; it possesses a pleasant taste and smell. A number of samples have been found that were quite mouldy, having probably been stored in a damp place. The sample used in the feeding experiment herein described had the following composition: —

	Bibby's Dairy Cake.	Standard Wheat Middlings for Comparison.	Gluten Feed for Comparison.
Water,	11.96	10.00	9.69
Ash,	7.89	4.30	1.40
Protein,	17.99	18.00	23.55
Fiber,	7.91	7.00	7.15
Extract matter,	45.05	55.70	55.08
Fat,	9.20	5.00	3.13

The cake has a high ash percentage, due partly to the presence of added salt, a moderate amount of protein and fiber, and quite a noticeable per cent. of fat. It is guaranteed to contain 18 to 20 per cent. of protein and 6 to 8 per cent. of fat, and usually meets these requirements. It has not been found to be very generally distributed.

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[1] With E. B. Holland, P. H. Smith and J. G. Cook.

[2] The locust or carob tree is cultivated in Spain, the eastern Mediterranean regions and Egypt. The pods contain considerable quantities of sugar, and are eaten by both men and animals.

Digestibility of Bibby's Dairy Cake.

The average results of six single trials with sheep are here given, together with the coefficients for standard wheat middlings and gluten feed for comparison. The full details of the digestion experiment have been reported in the seventeenth report of this station.

Coefficients of Digestibility.

	Bibby's Dairy Cake.	Standard Wheat Middlings for Comparison.	Gluten Feed for Comparison.
Dry matter,	70	73	85
Ash,	33	25	-
Protein,	66	77	85
Fiber,	31	30	76
Extract matter,	81	78	89
Fat,	92	88	83

In the several trials with Bibby's dairy cake the sheep experienced considerable difficulty in digesting the crude fiber, due probably to the fact that it was derived largely from cotton-seed hulls. It may be said that the total cake proved moderately digestible, the fiber having a low and the fat a high digestibility. Both in chemical composition and in digestibility Bibby's dairy cake closely resembled standard wheat middlings. Gluten feed contains 5 to 6 per cent. more protein, and is more digestible than the cake.

Cost of Digestible Matter.

	Bibby's Dairy Cake.	Standard Wheat Middlings.	Gluten Feed.
Pounds digestible matter in 2,000 pounds.	1,232	1,314	1,550
Cost of one pound (cents),	2.43	2.11	1.72

The above figures are based on the average wholesale prices of middlings and gluten feed for the year 1904, plus 10 per cent.; namely, $26.70 for middlings and $27.72 for gluten feed. Bibby's dairy cake cost $30 a ton. The calculations show that a ton of wheat middlings furnished rather more digestible matter than a ton of Bibby's dairy cake, and at a somewhat less cost a pound. They further show that, if 1,550 pounds of digestible matter in a ton of gluten feed could be purchased for $27.72, 1,232 pounds, being the quantity contained in a ton of Bibby's dairy cake, ought not to cost over $22. In other words, Bibby's dairy cake at $30 a ton furnishes digestible matter at some 37 per cent. advance over that contained in gluten feed at $27.72 a ton.

Feeding Experiment with Bibby's Dairy Cake, Spring, 1904.

In order to test the efficacy of this cake as a food for milk production, four cows were divided as evenly as possible into two groups, and fed by the reversal method. All of the cows received first-cut hay, rowen and bran as a basal ration. In the first half, two of the cows received a definite quantity of the dairy cake and the other two a like quantity of gluten feed; in the second half, these two grain feeds were reversed.

Duration of Experiment.

Periods.	DATES.	Gluten Feed Ration.	Bibby's Dairy Cake Ration.
I., . .	May 7 through May 27.	Red II. and Brighty.	Linnie and Blanche.
II., . .	June 4 through June 24.	Linnie and Blanche.	Red II. and Brighty.

Care of the Animals. — The cows were kept in roomy stalls, well carded, and turned into the yard some six or more hours each pleasant day.

Method of Feeding. — The animals were fed twice daily, the hay being given about an hour before milking, and the grain mixtures just before milking. The several grains were well mixed before being fed. Bibby's dairy cake was ground to the fineness of ordinary meal. Water was supplied the animals constantly by means of a self-watering device.

Character of Feeds. — The first-cut hay was a mixture of Kentucky blue-grass, timothy and red clover. The rowen was a mixture of second growth of grass and red clover, secured in good condition. The spring bran, gluten feed and Bibby's dairy cake were of good average quality.

Weighing the Animals. — The animals were weighed for three consecutive days at the beginning and end of each half of the trial.

Sampling Feeds. — The hay and rowen were sampled at the beginning, middle and end of each half of the trial, dry matter determinations made at once, and the several samples mixed for analysis. The grains were sampled daily, and preserved in glass-stoppered bottles. The cows received two ounces of salt daily.

Sampling the Milk. — The milk of each cow was sampled twice daily for five consecutive days of each week, and preserved with formaline in tightly corked bottles. The method of sampling consisted in mixing the freshly drawn milk with an especially constructed mixer, and immediately removing a small dipperful. Determinations of fat were made weekly, and solids every other week.

History of the Cows, Spring, 1904.

Name.	Breed.	Age (Years).	Last Calf dropped.	Number of Days with Calf.	Milk Yields, Beginning of Experiment (Pounds).
Red II., .	Jersey-Durham,	8	December, 1903.	59	30
Brighty, .	Grade Jersey, .	8	August, 1903.	124	17
Linnie, .	Grade Jersey, .	7	October, 1903.	65	21
Blanche, .	Grade Jersey, .	9	August, 1903.	121	22

Daily Rations consumed (Pounds).

Ration.	Cows.	Hay.	Rowen.	Bran.	Gluten Feed.	Bibby's Dairy Cake.
Gluten feed, . .	Red II., .	18	6	4	4	–
	Brighty, .	14	6	3	3	–
	Linnie, .	14	6	3	3	–
	Blanche, .	17	6	3	4	–
Bibby's dairy cake, .	Red II., .	18	6	4	–	4
	Brighty, .	14	6	3	–	3
	Linnie, .	14	6	3	–	3
	Blanche, .	17	6	3	–	4
Average, gluten feed ration.	. . .	15.75	6	3.25	3.5	–
Average, Bibby's dairy cake ration.	. . .	15.75	6	3.25	–	3.5

It will be seen that the cows received the same basal ration daily, and in addition averaged 3.5 pounds of gluten feed or dairy cake.

Average Dry Matter and Digestible Organic Nutrients in Daily Ration (Pounds).

RATION.	Dry Matter.	DIGESTIBLE ORGANIC NUTRIENTS.					Nutritive Ratio.
		Protein.	Fiber.	Extract Matter.	Fat.	Total.	
Gluten feed, average, .	24.99	2.36	4.15	7.73	.35	14.59	1: 5.4
Bibby's dairy cake, average.	24.91	2.07	3.96	7.27	.36	13.86	1: 6.0

The two rations furnished the same quantity of total dry matter daily. The Bibby's dairy cake ration contained rather less protein and about three-fourths of a pound less total digestible matter. This was due principally to the fact that Bibby's dairy cake was less digestible than the gluten feed. It would naturally be expected that Bibby's dairy cake ration would produce rather less milk, or cause the animals to shrink somewhat in live weight.

Total Yields of Milk Products (Pounds).

RATION.	Total Milk.	Average Daily Yield.	Total Solids.	Total Fat.	Butter Equivalent 85 Per Cent.
Gluten feed, ...	1,860.04	22.14	256.12	89.89	105.75
Bibby's dairy cake, ...	1,830.01	21.79	251.20	90.00	105.88

The yields obtained from the two rations, covering a period of twenty-one days in each case, were practically identical. If the periods had covered twice the length of time, the results would have been regarded as more satisfactory. Longer periods were not practicable, owing to the condition of the animals and the nearness of summer weather.

Average Composition of the Herd Milk.

RATION.	Total Solids (Per Cent.).	Fat (Per Cent.).
Gluten feed, ...	13.77	4.83
Bibby's dairy cake, ...	13.73	4.92

The two rations produced milk having practically the same composition.

Food Cost of Milk Products.

RATION.	Total Milk.	One Hundred Pounds Milk.	One Pound Butter.
Gluten feed, ...	$20 85	$1 12	$0 20
Bibby's dairy cake, ...	22 03	1 20	21
Percentage increased cost with Bibby's dairy cake.	5.66	7.14	5.00

In calculating the above results, gluten feed was charged at $27.72 a ton, Bibby's dairy cake at $30, bran at $20, hay at $15 and rowen at $14. The increased cost of the milk and butter produced by the Bibby's dairy cake ration was due to the price asked for Bibby's dairy cake.

Herd Gain or Loss in Live Weight.

RATION.	Total Gain or Loss.
Gluten feed, ...	43 +
Bibby's dairy cake, ...	2 —

There appeared to have been a slight gain in live weight produced by the gluten ration. During the Bibby's dairy cake period the weight remained constant.

Conclusions.

1. Bibby's dairy cake, a manufactured product, resembles in chemical composition and digestibility standard wheat middlings. It has a sweet taste and an agreeable flavor and odor, due to the presence of the carob bean, fenugreek and salt.

2. It was found to contain slightly less digestible matter than middlings, and some 20 per cent. less than gluten feed. On the basis of digestible matter contained in the Bibby's dairy cake and in first-class gluten feed, the former should sell for 20 per cent. less a ton.

3. While the cake is readily eaten and highly relished by

all farm animals, it is believed that the agreeable flavor and odor do not make it worth the extra price asked.

4. In the feeding experiment, lasting twenty-one days, the four cows produced practically as much milk on the Bibby's dairy cake as on the gluten feed ration; the latter ration produced a slight gain in live weight. The cost of milk and butter was noticeably more on the Bibby's dairy cake ration. The experiment indicates that the Bibby's dairy cake ration furnished a sufficient quantity of digestible matter to meet the requirements of the several cows. Had the periods been longer, and the cows in a less advanced period of lactation, it is believed the differences would have been more striking.

5. Bibby's dairy cake, at prevailing market prices, is not regarded as an economical concentrate; it can be used, however, if desired, as the exclusive grain ration for sheep, young dairy stock and milch cows. From 5 to 8 pounds would be the usual daily allowance for the latter animals. Its chief use should be as an appetizer, to be mixed in small quantities with foods that, because of an inferior flavor, would not be otherwise readily consumed.

From the standpoint of economy, farmers will do well to produce their hay, silage and corn meal, and to purchase only those manufactured concentrates that are rich in protein, such as cotton-seed meal, gluten feed, distillers' and brewers' dried grains, wheat middlings and bran.

2. EUREKA SILAGE CORN, — ITS VALUE FOR MASSACHUSETTS FARMERS.

J. B. LINDSEY AND P. H. SMITH.

This corn is said to have originated in Virginia. It is a large southern dent, and is considerably used for silage purposes by New England farmers.

Brooks[1] of this station compared a number of dent varieties during the season of 1901. The Eureka grew to be 15 feet high, appeared to be quite heavily leaved, and when cut, September 14, the ears were just forming. This variety yielded rather heavier than the others, producing at the rate of 24 tons to the acre, containing 8,944 pounds of dry matter. Its digestibility was not determined. Brooks concluded that the heavy dents were not as satisfactory as the smaller varieties for New England conditions. At the solicitation of Ross Bros. of Worcester, who recommend and sell the Eureka seed for silage purposes, this department has made a more thorough study of the Eureka, and briefly presents the results and conclusions in the following pages.

Crop of 1903.

One-fourth acre of medium well-drained loam, in a good state of fertility, was treated with manure from well-fed dairy cows, at the rate of 6 cords to the acre. The manure was plowed in, and the land well fitted and seeded May 26, with Eureka corn, obtained of Ross Bros. The seed came up well, and the corn made as good growth as could be expected during the exceptionally cool season. Frosts held off until nearly the 1st of October, and the corn was allowed to grow until September 25, in order to insure a maximum development. At that time it averaged 11½ feet in height, the ears had formed, and the kernels were just beginning to develop. When cut, it contained 82.6 per cent. of water, and yielded at the rate of 15 tons of green material to the acre.

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[1] Fourteenth annual report of the Hatch Experiment Station, pp. 32–34.

Crop of 1904.

One-third of an acre of well-drained, light loam was plowed, manured at the rate of 6 cords to the acre and well fitted. The area was divided into two halves, and planted with Eureka and Sibley's Pride of the North corn, the latter a medium dent that will mature its seed in our latitude. Some of the seed failed to germinate, more particularly the Eureka, which necessitated some replanting. When the corn was 15 inches high it was thinned to about one stalk to the foot. The area was kept well cultivated and free from weeds. On July 12 the corn was growing fast and looked healthy, the Eureka being the taller. August 15 the Pride of the North was well tasseled and silked, while the Eureka tassels were just showing. The corn was cut September 15, at which time the Pride of the North averaged 9 to 10 feet in height and was fairly ripe, with kernels glazing. The Eureka was 12 to 13 feet high and quite immature, the ears being small and the kernels scarcely formed. Two plats, each 175 by 35 feet, were cut, stooked and eventually carried to the barn and carefully weighed. The Eureka yielded 936 pounds of dry matter, equal to 6,683 pounds per acre, equivalent to 20.4 tons of green corn (83.6 per cent. water); the Pride of the North yielded 877 pounds of dry matter, equal to 6,262 pounds per acre, equivalent to 13.9 tons of green corn (77.5 per cent. water).

Composition of Green Corn (Per Cent.).

	EUREKA.		Pride of the North, **1904.**
	1903.	**1904.**	
Water,	82.60	83.60	77.50
Ash,	1.08	1.08	1.05
Protein,	1.63	1.48	1.85
Fiber,	4.77	5.48	4.97
Nitrogen-free extract,	9.65	8.11	14.06
Fat,	.27	.25	.57
	100.00	100.00	100.00

The above analyses show that the Eureka, when cut in September, contained considerably more water and noticeably less nitrogen-free extract matter and fat than the Pride of the North.

Composition of Dry Matter (Per Cent.).

	Whole Plant.				Stover.		
	Eureka.			Pride of the North, **1904.**	Eureka, **1904.**	Pride of the North, **1904.**	Average, Forty-one Analyses, for Comparison.
	1903.		**1904.**				
Ash,	6.19[1]	7.85[2]	6.58	4.67	6.96	6.77	6.60
Protein,	9.34	9.82	9.01	8.22	8.00	7.23	7.60
Fiber,	27.41	32.70	33.43	22.11	36.49	34.45	34.20
Extract,	55.52	47.90	49.47	62.47	47.19	50.01	50.20
Fat,	1.54	1.73	1.51	2.53	1.36	1.54	1.40
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[1] When cut in autumn. [2] After being housed in barn until March.

The differences in the composition are much more noticeable with the water eliminated. The Eureka (whole plant) contained decidedly more ash and fiber, rather more protein and much less extract matter than the Pride of the North.

The analyses show that the Pride of the North had reached a more advanced stage of development than the Eureka, and consequently contained a much larger proportion of starchy matter. The stover from the two varieties was quite similar in composition.

Percentage of Water in Field-cured Material.

Eureka.			Pride of the North.	
Whole Plant.		Stover.	Whole Plant.	Stover.
59.92[1]	68.92[2]	62.89[3]	37.84[4]	18.13[5]

[1] After being cured in barn for six months, 1903. [2] As it came from field, 1904.
[3] After being in barn about a month, 1904. [4] As it came from field, 1904.
[5] After being in barn about three months.

The field-cured Eureka still continued to contain a high moisture content, due probably to its immaturity and to its unusually coarse, porous stems.

The Pride of the North had about the usual water content for matured corn that had been field cured. These figures show that in a ton of dried Eureka fodder, as drawn to the barn, there would be 1,380 pounds of water and 620 pounds of dry matter; and in a ton of Pride of the North there would be 757 pounds of water and 1,243 pounds of dry matter; in other words, each ton of Pride of the North would have twice the feeding value of Eureka, without taking into consideration the superior nutritive character of the dry matter, which will be alluded to under another heading.

The corn stover derived from the two varieties likewise showed marked differences in the water percentage present. The barn-cured Pride of the North stover was exceptionally dry.

Composition of Parts of Corn (Per Cent.).

[Dry Matter.]

	LEAVES.		STALKS.		EARS.		HUSKS.	
	Eureka.	Pride of the North.	Eureka.	Pride of the North.	Eureka.	Pride of the North.	Eureka.	Pride of the North.
Ash, ...	8.98	9.42	5.42	5.81	3.25	1.95	3.02	3.17
Protein, . . .	14.53	14.53	4.80	4.55	12.00	9.82	8.66	5.40
Fiber, ...	28.43	25.00	35.77	31.94	19.47	11.37	24.64	27.32
Extract, . . .	45.63	47.63	52.94	56.82	63.84	73.65	62.22	62.70
Fat, ...	2.43	3.42	1.07	.88	1.44	3.21	1.46	1.41
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The samples were taken immediately after the corn was cut (September 15), dried at a low heat, and preserved in glass-stoppered bottles. The leaves of the two varieties were similar in composition, and are the most valuable parts of the plant, aside from the ears. The stalks of the Eureka were characterized by containing more fiber than the other variety. The ears produced by the Eureka contained rather more protein and ash, decidedly more fiber and noticeably less fat and extract matter than those yielded by the Pride of the North. The analyses make clear that the ears obtained from the Eureka were quite imperfectly developed. The composition of the husks was more uniform.

Digestibility of the Corn.

The first digestion experiment was made in the autumn of 1903, with the Eureka green corn. Another experiment was made with the same corn, after it had been cured and housed for six months. Unfortunately, a digestion test was not made with the Pride of the North (whole plant). During the autumn of 1905, therefore, another sample of this variety was tested for digestibility. It was fully developed and well eared. Other experiments were made to test the digestibility of the stover of each of the two varieties produced in 1904. The several tests were made with the same sheep in each case, the results of which follow : —

	EUREKA.		Pride of the North, Green, **1905** (Two Sheep).	Eureka, Stover, **1904** (Two Sheep).	Pride of the North, Stover, **1904** (Two Sheep).
	Green, **1903** (Three Sheep).	Dry, **1903** (Two Sheep).			
Dry matter,	67	64	71	54	54
Ash,	42	40	34	45	31
Protein,	67	57	63	48	45
Fiber,	60	72	65	59	60
Nitrogen-free extract,	72	64	77	53	54
Fat,	66	62	76	67	64

The green Eureka fodder (whole plant) and the same material dried showed only slight variation in the digestibility of total dry matter. The results correspond closely with those obtained by other experimenters with large southern varieties at a similar stage of growth. For some reason the fiber in the dry material was more fully digested than in the green substance, and the protein and extract matter less so. The Pride of the North (whole plant) proved to be rather more digestible than the Eureka, due to the fact that it was well eared. The digestible material in the Pride of the North, because of its content of matured grain, would naturally yield more net available energy than a like amount of digestible matter derived from the Eureka. The corn stover (all ears removed) from each of the two varieties appeared to be equally well digested.

Summary of Yields.

A definite quantity of each of the two varieties of green material was separated into husks, ears, leaves and stalks, in order to determine the relative proportions of each. The figures show percentages or pounds in 100.

(a) Yield of Parts.

PARTS.	EUREKA.			PRIDE OF THE NORTH.		
	First Trial.	Second Trial.	Average.	First Trial.	Second Trial.	Average.
Husks, ...	6.50	8.00	7.25	10.25	11.25	10.75
Ears, ...	6.25	8.25	7.25	21.25	23.00	22.11
Leaves, ...	22.75	21.75	22.25	20.00	20.00	20.00
Stalks, ...	65.00	62.25	63.62	47.50	46.00	46.75
	100.50	100.25	100.37	99.00	100.25	99.67

The results are in accordance with the teaching of the analytical data. The Eureka showed only 7.25 per cent. of ears, while the Pride of the North contained 22.11 per cent. The Pride of the North variety consisted of 46.75 per cent. of stalks, and the Eureka 63.62 per cent. The Eureka, even at its less advanced stage of growth, contained only slightly more leafy matter than the Pride of the North.

(b) Yield per Acre (Pounds).

	EUREKA.		Pride of the North, **1904.**
	1903.	**1904.**	
Green material, ...	30,000	40,800	27,800
Dry matter, ...	5,220	6,691	6,255
Estimated digestible matter, . . .	3,497 [1]	4,483 [1]	4,441 [1]

[1] Obtained by allowing 67 per cent. of the dry matter to be digestible in the Eureka, and 71 per cent. in the Pride of the North, as determined by actual experiment.

The above results indicate strongly that the Eureka, although a larger variety, yielding considerable more green material than the Pride of the North, is not likely to furnish any more actual food to the acre. In the present instances, the party drawing the product of an acre of green Eureka corn to the barn would be transporting 34,109 pounds of water and 6,691 of dry matter, while in the case of the Pride of the North he would cart 21,545 pounds of water and 6,255 pounds of dry material ; in other words, to secure essentially the same quantity of actual food in the Eureka he would be required to handle 12,564 pounds extra water.

It is, of course, understood that the yield would vary from year to year, depending on soil and climatic conditions. It is believed, however, that the relative proportions would hold true, and that the farmer would secure as much actual food material from those varieties of corn that mature their seed, without being obliged to handle the extra bulk in the form of water.

Conclusions.

1. Eureka silage corn is a late dent variety ; it has large stalks, which appear to be thickly set with leaves. During the seasons of 1903 and 1904 it grew 11 to 13 feet high, and when cut, September 15, the ears were very immature (kernels just forming).

2. In comparison with Sibley's Pride of the North, a medium dent, which matures its ears in this latitude, the Eureka green corn, when cut, contained about 6 per cent. more water, noticeably more ash and fiber, and much less extract matter. The field-cured fodder of the Eureka still contained as high as 69 per cent. of water, while the Pride of the North contained only 38 per cent.

3. The leaves and husks of each variety did not vary greatly in composition. The ears and stalks of the Eureka contained more fiber and much less extract matter and fat than those of the Pride of the North.

4. The Eureka green fodder was found to be 67 per cent., and the same material dry 64 per cent., digestible ; a typical sample of Pride of the North, cut green, was 71 per cent. digestible. The stover of both varieties proved equally digestible.

5. The Eureka yielded about the same relative weight of green leaves as did the Pride of the North. It produced 64 per cent. of stalks and 7 per cent. of ears, while the Pride

of the North yielded 47 per cent. of stalks and 22 per cent. of ears.

6. The Eureka produced at the rate of 20 tons of green fodder, and the Pride of the North 13 tons of green fodder, to the acre. The latter, however, contained nearly as much dry and digestible matter (actual food material) as did the former. The excess yield of Eureka green corn, therefore, consisted of water.

7. Had the seasons of 1903 and 1904 been more favorable to the growth of corn, it is probable that both varieties would have produced larger yields. It is very doubtful, however, if the Eureka would have matured its grain.

The writer, therefore, thinks it unwise to grow such late dents as the Eureka, and believes the northern farmer will secure better feed for less money by holding fast to those varieties that will mature not later than September 10 or 15.

It is well known that immature corn, such as the Eureka, undergoes more serious decomposition when ensiled than do well-matured varieties, which would still further detract from its nutritive value.

3. Concerning Wheat Bran.

J. B. LINDSEY.[1]

(1) *Introduction.*

Until within comparatively recent times, wheat bran and corn meal have formed the two staple concentrated feeds for dairy stock, and in spite of the large variety of concentrates now in the market, the former still continues to be used largely by the great majority of dairymen in our eastern States. The reasons for this are not difficult to find. A good quality of bran is uniformly palatable ; it can be fed in considerable quantities without producing any ill effects ; it acts as a slight laxative ; it furnishes more digestible protein than corn ; and it serves as a very satisfactory diluter or distributer of the heavy concentrates, such as the glutens, cotton-seed meal and flour middlings. It is believed, however, that the nutritive material contained in bran can be purchased more cheaply in other concentrates, and that New England farmers often use more of it than economy warrants.

Attention is called in the present paper to the composition, digestibility, cost of digestible matter and the fertilizer ingredients in bran, as compared with other concentrated feeds, and likewise to experiments I. and II., in which corn silage is compared with wheat bran as a distributer of the heavy concentrates. Note particularly the brief discussion of the results, at the end of the article.

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[1] With E. B. Holland, P. H. Smith and J. G. Cook.

(2) *Average Composition of Concentrates.*

INGREDIENTS.	Wheat Bran.	FOR COMPARISON.				
		Cotton-seed Meal.	Gluten Feed.	Distillers' Dried Grains.	Brewers' Dried Grains.	Malt Sprouts.
Water, ...	10.00	7.00	8.50	8.00	8.00	11.00
Ash, ...	6.40	6.50	1.70	1.70	3.80	5.80
Protein, ...	16.00	45.10	26.50	33.00	23.10	27.10
Fiber, ...	10.00	6.10	7.20	13.10	10.80	11.80
Extract matter (starchy),	53.00	24.20	53.10	32.40	49.40	42.90
Fat, ...	4.60	11.10	3.00	11.80	4.90	1.60

Wheat bran contains noticeably less protein than any of the other important by-products. Nitrogen-free extract matter usually is the fodder group next in value to the protein. The quantity contained in bran is approximately equal to that found in gluten feed, and not greatly in excess of the percentage in brewers' grains and malt sprouts.[1] Most of the several feeds enumerated contain about similar fiber percentages.

(3) *Digestibility of the Concentrates.*

The figures in the following table show the pounds of digestible fodder groups contained in one ton of the several feeds.

Wheat bran is shown to contain rather less total digestible matter and noticeably less digestible protein than any of the several feeds tabulated. The two carbohydrate feeds, corn and hominy meals, are naturally deficient in protein, but very rich in digestible starchy matter and fat.

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[1] The quantity of extract matter in cotton-seed meal is quite small, due to the exceptionally high protein percentage.

Organic Matter digestible in 2,000 Pounds.

INGREDIENTS.	Wheat Bran.	Cotton-seed Meal.	Gluten Feed.	Brewers' Dried Grains.	Malt Sprouts.	Distillers' Dried Grains.	Corn Meal.	Hominy Feed.
Protein,	254	800	440	364	434	448	130	142
Fiber,	58	68	110	114	78	160	-	44
Extract matter,	732	298	964	574	580	520	1,328	1,110
Fat,	60	196	50	90	32	206	60	152
Totals,	1,104	1,362	1,564	1,142	1,124	1,334	1,518	1,448

Retail Cost of One Pound of Digestible Matter.

	Spring and Winter Bran. **1901** to **1904.**	Cotton-seed Meal. **1901** to **1904.**	Gluten Feed. **1901** to **1904.**	Distillers' Dried Grains. **1904** to July, **1905.**	Brewers' Dried Grains. **1904.**	Malt Sprouts. **1904** to July, **1905.**	Corn Meal. **1901** to **1904.**	Hominy Meal. **1901** to **1904.**
Market price per ton,	$22 48	$29 17	$26 05	$27 00	$22 50	$21 00	$26 12	$25 03
Cost of one pound of digestible matter (cents),	2.04	2.15	1.67	2.03	1.97	1.87	1.70	1.72

The above figures are quite instructive. They show that digestible matter in bran, cotton-seed meal and distillers' and brewers' dried grains has cost about the same for a number of years, while in the form of malt sprouts the price has been somewhat less.[1] Corn and corn by-products (gluten and hominy feed) have furnished digestible matter for uniformly less money than it could be purchased for in the form of either bran, cotton-seed meal, distillers' or brewers' residues.

Retail Cost of Digestible Protein.

[Allowing 1 cent for digestible carbohydrates, .5 cent for digestible fiber and 2.25 cents for digestible fat.]

	Spring and Winter Bran. **1901** to **1904.**	Cotton-seed Meal. **1901** to **1904.**	Gluten Feed. **1901** to **1904.**	Distillers' Grains. **1904** to July, **1905.**	Brewers' Grains. **1904.**	Malt Sprouts. **1904.**
Market price per ton, .	$22 48	$29 17	$26 05	$27 00	$22 50	$21 00
Cost of one pound of digestible protein (cents).	5.40	2.72	3.00	3.65	3.91	3.25

Cotton-seed meal furnishes digestible protein for the least money, gluten feed standing next in order, while protein in the form of wheat bran is decidedly expensive. Naturally, carbohydrate feeds, corn and the like, are not economical sources of protein.

(4) *Fertilizing Ingredients in a Ton of Concentrates.*

	Wheat Bran.	Cotton-seed Meal.	Gluten Feed.	Distillers' Grain.	Brewers' Grains.	Malt Sprouts.
Nitrogen, ...	51	144	85	106	74	86
Potash, ...	28	37	-	-	17	33
Phosphoric acid, . .	42	50	7	60	21	29
Valuation per ton, . .	$12 34	$30 18	$16 00	$19 78	$15 25	$18 47
Percentage valuation of retail cost.	54	103	62	73	68	88

Bran is quite rich in the mineral ingredients phosphoric acid and potash, being exceeded only by cotton-seed meal.

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[1] The retail price of malt sprouts and brewers' dried grains has been rather difficult to ascertain, for the reason that comparatively small quantities are sold in Massachusetts markets.

The corn by-products (gluten feed and distillers grains) contain only a trace of potash. The money valuations are based on current market prices, namely: nitrogen, 18.5 cents; potash, 4.25 cents; and phosphoric acid, 4 cents a pound. The fertilizing elements in the several feeds are in as desirable a form as those in the best grades of unmixed fertilizing stock. Bran is shown to contain fertilizer ingredients equal to 54 per cent. of its cost, and cotton-seed meal is fully equal to its cost; the others are considerably in excess of the bran.

It is not to be inferred that after the several feeds have passed through the animal their fertilizing ingredients have as high a money value as before they were consumed. In fact, some 20 per cent. has been retained by the animal, more or less loss has unavoidably occurred in the manurial residue, and they are in a much more bulky condition, which requires considerable additional labor to apply them. Nevertheless, the figures show clearly that the combined fertilizer ingredients in bran have noticeably less value than in any of the other by-products.

Conclusions.

1. Wheat bran contains noticeably less total as well as less digestible protein than any of the other nitrogenous by-products.

2. The total digestible matter in bran is likewise less than in the other prominent concentrates; thus, cotton-seed meal contains 24 per cent. more, gluten feed 44 per cent., distillers' grains 21 per cent. and corn meal 38 per cent.

3. For several years past the cost of a pound of digestible matter in bran, cotton-seed meal, distillers' and brewers' dried grains has been about the same; it could be purchased in the form of gluten feed, corn and hominy meals for some 20 per cent. less.

4. A pound of digestible protein in wheat bran cost 100 per cent. more than in cotton-seed meal, 80 per cent. more than in gluten feed and 50 per cent. more than in distillers' dried grains.

5. Because of its relatively low protein percentage, the

fertilizer ingredients in bran have from 10 to 50 per cent. less money value than those contained in the other by-products.

6. The nutritive material and especially the protein contained in wheat bran must be regarded, therefore, as relatively expensive. Because of its palatability, its laxative effect and its desirability as a diluter or distributer of the heavy concentrates, it will continue to be used by many farmers as a portion of the grain ration for dairy stock. See practical deductions as to the use of bran, on page 114.

(5) *Wheat Bran* v. *Corn Silage as a Distributer of the Heavy Concentrates.*

EXPERIMENT I. SPRING, 1903.

Object of the Experiment. — Wheat bran has been shown to be an expensive feed, judged solely from the amount of nutritive material it contains. The present experiment was undertaken to see if silage would not serve as a distributer equally as well as bran. Such being the case, the farmer could use *home-grown* corn, or corn and cob meal, in place of an equal amount of bran, and, by feeding in addition a few pounds daily of cotton-seed meal and malt sprouts or flour middlings, get along with a minimum quantity of *purchased* grain.

Plan of the Experiment. — The cows, ten in number, were high-grade Jerseys. Eight had calved early the previous autumn, and two, Pearl and Red 2d, the preceding December.

The animals were divided as equally as possible into two lots of five each, and both herds fed for two weeks upon the so-called bran ration, consisting of silage, hay, cotton-seed meal, flour middlings and wheat bran. In the second period, lasting five weeks, one lot of cows, known as Herd I., continued to receive the same ration; and the other lot, Herd II., was fed the so-called silage ration, consisting of silage and hay, cotton-seed meal, flour middlings and corn and cob meal. In each of the two periods one week was considered preliminary.

In interpreting the results, it is proposed to note the weekly yields produced in the second period by both herds on different grain rations, as compared with the weekly yields of the first periods, when the two herds received the same grain ration, thus ascertaining the comparative efficacy of the two different grain rations fed in the second period. The yields obtained in the first period are to be used simply as a basis for comparison.

Duration of the Experiment.

Period I.

Herd.	Character of Ration.	Cows.	Date.	Number of Weeks.
I., .	Bran as distributer,	Brighty, Pearl, Linnie, Roda, Doliska.	March 30[1]-April 5.	1
II., .	Bran as distributer,	Red II., Dora, Blanche, May, Daisy.	March 30-April 5.	1

Period II.

Herd.	Character of Ration.	Cows.	Date.	Number of Weeks.
I., .	Bran as distributer,	Brighty, Pearl, Linnie, Roda, Doliska	April 12[1]-May 10.	4
II., .	Silage as distributer,	Red II., Dora, Blanche, May, Daisy.	April 12-May 10.	4

[1] Preceded by preliminary period of seven days.

General Care of the Animals. — The experiment was carried out in the station barn, especially set apart for such work. Each animal was kept in a roomy stall, well carded, and turned daily into a yard for exercise. The cows were in good condition, and quite contented.

Method of Feeding. — The cows were fed twice daily, and water was before them constantly. In case of the bran ration, the several grains composing it were carefully mixed, and fed just before milking. The grains used in the silage ration — cotton-seed and corn meals and flour middlings — were likewise mixed, and the resulting combination quite thoroughly mingled with the silage by means of a four-tined fork, and fed previous to milking. One quart of the bran ration weighed .80 of a pound, and 1 quart of the grain ration fed with the silage weighed 1.4 pounds, the former being naturally much more bulky.

Character of the Feed Stuffs. — The bran was from spring wheat, the other grains were of the usual good quality. The silage, made from rather poorly eared corn, was of average quality. The hay was largely Kentucky blue-grass, with some clover.

Weighing the Animals. — The animals were weighed on three consecutive days at the beginning and end of the second period.

Sampling Feeds. — The coarse fodders were sampled three times during the second period, dry matter determinations made immediately, and composite samples analyzed. Small samples of the grains were taken daily and placed in glass-stoppered bottles.

Sampling Milk. — The milk of each cow was sampled twice daily for five consecutive days of each week of the two periods, and preserved with formaline in tightly corked bottles. The method of sampling consisted in mixing the freshly drawn milk with an especially constructed mixer, and immediately removing a small dipper full.

Average Ration consumed by Each Cow Daily (Pounds).

First period: both herds, bran ration.

HERD.	First Cut Hay.	Silage.	Bran.	Cotton-seed Meal.	Flour Middlings.	Corn and Cob Meal.
I., ...	12.52	26.10	3.60	2.00	2.00	–
II., ...	13.60	29.00	3.80	2.10	2.10	–

Second period: Herd I., bran ration; Herd II., silage ration.

HERD.	First Cut Hay.	Silage.	Bran.	Cotton-seed Meal.	Flour Middlings.	Corn and Cob Meal.
I., ...	12.80	25.70	3.60	2.00	2.00	–
II., ...	13.60	29.00	–	2.10	2.10	3.80

Herd I. received practically the same quantity of grain and roughage daily in each period; the same can be said of Herd II. Herd II. needed and received slightly more than Herd I. during both periods.

Average Dry and Digestible Daily Nutrients consumed by Each Cow (Pounds).

Herd I.: both periods, bran ration.

PERIOD.	Dry Matter.	Protein.	Carbo-hydrates.	Fat.	Total.	Nutritive Ratio.
I., . . .	22.98	2.42	11.38	.69	14.49	1:5.4
II., . . .	23.16	2.43	11.46	.69	14.58	1:5.4
Herd II.: first period, bran ration; second period, silage ration.						
I., . . .	24.85	2.58	12.36	.74	15.68	1:5.4
II, . . .	24.78	2.26	13.29	.73	16.28	1:6.5

Herd I. received the same quantity of digestible nutrients during both periods. Herd II. received more total digestible matter in the first period than did Herd I., but the nutritive ratio of the fodder groups was the same. In the second or silage period Herd II. consumed rather more total digestible nutrients than in the first period, but less digestible protein, the nutritive ratio being somewhat wider (1 : 6.5, instead of 1 : 5.4). This increase of digestible matter consumed was due to the higher digestibility of the corn and cob meal.

Weight of Animals at Beginning and End of Second Period (Pounds).

HERD.		Brighty.	Pearl.	Linnie.	Roda.	Doliska.	Red II.	Dora.	Blanche.	May.	Daisy.	Gain or Loss.
I., .	Beginning, .	850	958	815	860	761	–	–	–	–	–	+67
	End, . .	874	967	828	864	778	–	–	–	–	–	
II., .	Beginning, .	–	–	–	–	–	1,003	875	1,168	1,048	850	+94
	End, . .	–	–	–	–	–	1,003	905	1,177	1,076	877	

Each herd made a slight gain during the period. The difference is unimportant.

Yield of Milk and Milk Ingredients (Pounds).

First period: both herds, bran ration.

Herd.	Cows.	Total Milk.	Daily for Cow.	Total Solids.	Total Fat.	Butter Equivalent (85 Per Cent.).
I.,	Brighty,	127.25	18.18	20.06	8.21	9.66
	Pearl,	218.00	31.14	29.89	10.90	12.82
	Linnie,	157.00	22.43	22.62	8.48	9.98
	Roda,	110.74	15.82	15.32	5.65	6.65
	Doliska,	184.99	26.43	23.29	7.03	8.27
Total,		797.98	114.00	111.18	40.27	47.38
II.,	Red II.,	262.49	37.50	32.31	11.02	12.96
	Dora,	142.60	20.37	20.29	7.27	8.55
	Blanche,	150.62	21.52	22.61	7.91	9.31
	May,	139.50	19.93	21.41	7.88	9.27
	Daisy,	123.00	17.57	19.45	7.38	8.68
Total,		818.21	116.89	116.07	41.46	48.77

Second period: Herd I., bran ration; Herd II., silage ration.

I.,	Brighty,	509.74	18.21	80.84	32.41	38.13
	Pearl,	879.70	31.42	125.70	46.44	54.65
	Linnie,	679.00	24.25	97.84	36.60	43.06
	Roda,	439.82	15.71	62.37	22.17	26.08
	Doliska,	773.21	27.61	97.73	29.15	34.30
Total,		3,281.47	117.20	464.48	166.77	196.22
II.,	Red II.,	1,048.58	37.45	131.91	43.62	51.32
	Dora,	581.83	20.78	85.65	31.48	37.04
	Blanche,	609.73	21.78	92.25	32.01	37.66
	May,	497.49	17.77	78.11	27.96	32.89
	Daisy,	480.68	17.17	77.53	29.99	35.28
Total,		3,218.31	114.95	465.45	165.06	194.19

Average Weekly Yields of Each Herd (Pounds), and Percentage Gain or Loss.

Herd I.

Periods.	Milk.	Solids.	Fat.	Butter Equivalent (85 Per Cent.).
I.,	798.0	111.2	40.3	47.4
II.,	820.4	116.1	41.7	49.1
Percentage gain or loss, II. over I.,	+2.8	+4.4	+3.5	+3.6
Herd II.				
I.,	818.2	116.1	41.5	48.8
II.,	804.6	116.4	41.3	48.5
Percentage gain or loss, II. over I.,	−1.7	+.3	−.4	−.6

It will be seen that Herd I., which received the bran ration during both periods, made a slight gain during the second period in the quantity of milk and milk ingredients; while Herd II., which received the silage ration in the second period, underwent a slight loss. The differences are so slight as to prevent any positive conclusions. They indicate, however, that the bran ration produced slightly better results than the silage ration, due possibly to the excess of protein in the former ration.

Dry and Digestible Matter required to produce Milk, Milk Solids and Milk Fat.

Herd I.: both periods, bran ration.

Period.	Dry Matter required to produce —			Digestible Matter required to produce —		
	One Hundred Pounds Milk.	One Pound Solids.	One Pound Fat.	One Hundred Pounds Milk.	One Pound Solids.	One Pound Fat.
I.,	100.80	7.23	19.97	63.56	4.56	12.60
II.,	98.81	6.98	19.44	62.21	4.40	12.24
Herd II.: first period, bran ration; second period, silage ration.						
I.,	106.32	7.49	20.98	67.04	4.73	13.23
II.,	107.78	7.45	21.01	70.83	4.90	13.81

Herd I. required slightly less dry and digestible matter to make milk and milk ingredients in the second period. Herd II. took a little more dry and digestible matter in the second period to make a definite quantity of milk, milk solids and milk fat. On the basis of the above figures, it may be concluded that the bran ration produced a trifle better results than the silage ration.

Food Cost of Milk and Butter.

Herd I.: both periods, bran ration.

Period.	One Hundred Pounds Milk.	One Hundred Pounds Butter.
I.,	$1 03	$17 33
II.,	1 01	16 81

Herd II.: first period, bran ration; second period, silage ration.

Period.	One Hundred Pounds Milk.	One Hundred Pounds Butter.
I.,	$1 08	$18 11
II.,	1 13	18 74
Percentage increased cost, Period II. over Period I.	+4.6	+3.5

The cost of milk and butter is based upon hay at $15 a ton, silage at $3.50, bran at $22, corn and cob meal at $26, cotton-seed meal at $30 and middlings at $25. The cost of milk and butter produced by Herd I. in both periods was nearly identical, and the slight variations may be attributed to experimental error. The increased cost of the milk and butter produced by Herd II. in the second period was due largely to the then existing excess cost of the corn and cob meal over that of the bran, and not to the feeding effect of the two rations.

Fertilizer Ingredients in Rations (Cost).

First period: Herd I., bran ration.

19.46 pounds nitrogen, valued at	$3 31
13.81 pounds potash, valued at	69
7.75 pounds phosphoric acid, valued at	31
Total,	$4 31

Fertilizer Ingredients, etc. — Concluded.

First period: Herd II., bran ration.

20.90 pounds nitrogen, valued at	$3 55
14.98 pounds potash, valued at	75
8.26 pounds phosphoric acid, valued at	33
Total,	$4 63

Second period: Herd I., bran ration.

78.16 pounds nitrogen, valued at	$13 29
55.65 pounds potash, valued at	2 78
31.02 pounds phosphoric acid, valued at	1 24
Total,	$17 31

Second period: Herd II., silage ration.

78.38 pounds nitrogen, valued at	$13 32
54.89 pounds potash, valued at	2 74
24.86 pounds phosphoric acid, valued at	99
Total,	$17 05

The total quantity and valuation of fertilizer ingredients were nearly identical in each ration.

Conclusions.

1. The animals were in good condition during the entire experiment, hence the silage proved equally as satisfactory as bran for distributing the heavy concentrates (cotton-seed meal and flour middlings).

2. The so-called bran ration produced a trifle more milk and milk ingredients than did the silage ration. Furthermore, it required a little less dry and digestible matter to make a definite quantity of milk ingredients with the former ration.

3. It cost several per cent. more to produce milk with the silage ration; but this difference was due primarily to the temporarily increased market price of the corn and cob meal, and not to the feeding effect of the ration.

EXPERIMENT II. — WINTER, 1904.

Object of the Experiment. — The object of this experiment was quite similar to the one already described; namely, to see if corn silage could not be employed in place of wheat bran as a distributer of the heavy concentrates.

Plan of the Experiment. — This experiment was conducted on the reversal plan. The cows were divided into two lots of four each. In the first half of the experiment one lot received the so-called bran ration at the same time the other lot received the silage ration. In the second half these conditions were reversed.

Duration of Experiment.

First Half.

CHARACTER OF RATION.	Date.	Number of Weeks.	Cows.
Bran as distributer, . . .	January 16 through February 26.	6	Blanche, Brighty, Doliska, Dora.
Silage as distributer, . . .	January 16 through February 26.	6	Daisy, Linnie, May, Roda.

Second Half.

CHARACTER OF RATION.	Date.	Number of Weeks.	Cows.
Bran as distributer, . . .	March 5 through April 15.	6	Daisy, Linnie, May, Roda.
Silage as distributer, . . .	March 5 through April 15.	6	Blanche, Brighty, Doliska, Dora.

Care of Animals and of the Product. — The general care of the animals and the method of feeding and of sampling the milk have been described in the preceding experiment. Each cow was weighed for three consecutive days at the beginning and end of each half of the experiment, the weighing being done in the afternoon before feeding and watering.

Character of the Feeds. — The weights of a quart of the two grain mixtures were about the same as those fed in the former experiment, the bran ration being much the more bulky. The bran was derived from winter wheat, and was light and flaky. Corn meal was used in place of corn and cob meal, the latter not being available. The cotton-seed meal and flour middlings were of the usual good quality.

The silage was largely corn, with a slight admixture of soy beans. The corn and soy beans were grown together, but, owing to the cool summer of 1903, the beans made a very light growth and produced scarcely any seeds. The corn, likewise, was poorly eared, and the total yield of the mixture was only about 8 tons to the acre. The silage was not at all decomposed or unduly acid, and was considered of fair quality. The hay was largely Kentucky blue-grass, of good quality, cut when in full to late blossom.

Rations consumed Daily (Pounds).

Wheat Bran Ration.

Cows.	First Cut Hay.	Silage.	Bran.	Corn Meal.	Flour Middlings.	Cotton-seed Meal.
Blanche, . . .	16.0	34.6	3.5	–	2.0	1.5
Brighty, . . .	13.0	30.0	3.0	–	2.0	1.0
Doliska, . . .	12.0	30.0	3.0	–	2.0	1.0
Dora, ...	13.0	30.0	3.0	–	2.0	1.0
Daisy, . . .	13.0	30.0	3.0	–	2.0	1.0
Linnie, . . .	15.0	30.0	3.0	–	2.0	1.0
May, ...	16.0	30.0	3.0	–	2.0	1.0
Roda, ...	12.0	30.0	3.0	–	2.0	1.0
Average, . .	13.8	30.6	3.1	–	2.0	1.1

Silage Ration.

Blanche, . . .	15.0	35.0	–	3.0	2.0	2.0
Brighty, . . .	12.0	30.0	–	2.5	2.0	1.5
Doliska, . . .	11.0	28.1	–	2.2	2.0	1.4
Dora, ...	12.0	30.0	–	2.5	2.0	1.5
Daisy, . . .	12.0	30.0	–	2.5	2.0	1.5
Linnie, . . .	14.0	30.0	–	2.5	2.0	1.5
May, ...	14.0	26.9	–	2.3	1.8	1.4
Roda, ...	11.0	30.0	–	2.5	2.0	1.5
Average, . .	12.6	30.0	–	2.5	2.0	1.5

Dry and Digestible Matter in Daily Rations (Pounds).

Wheat Bran Ration.

Cows.	Dry Matter.	Digestible Organic Nutrients.					Nutritive Ratio.
		Protein.	Fiber.	Extract Matter.	Fat.	Total.	
Blanche, . . .	27.12	2.54	4.36	8.45	.63	15.98	1:5.6
Brighty, . . .	22.66	2.09	3.61	7.21	.53	13.44	1:5.7
Doliska, . . .	21.78	2.04	3.43	6.98	.52	12.97	1:5.7
Dora, ...	22.66	2.09	3.61	7.21	.53	13.44	1:5.7
Daisy, ...	22.66	2.09	3.61	7.21	.53	13.44	1:5.7
Linnie, ...	24.44	2.18	3.97	7.67	.54	14.36	1:5.9
May, ...	25.33	2.23	4.15	7.89	.55	14.82	1:6.0
Roda, ...	21.78	2.04	3.43	6.98	.52	12.97	1:5.7
Average, . .	23.55	2.16	3.77	7.45	.54	13.92	1:5.7

Silage Ration.

Cows.	Dry Matter.	Protein.	Fiber.	Extract Matter.	Fat.	Total.	Nutritive Ratio.
Blanche, . . .	26.28	2.46	4.15	9.03	.68	16.32	1:5.9
Brighty, . . .	21.76	2.03	3.40	7.60	.57	13.60	1:6.0
Doliska, . . .	20.15	1.90	3.14	7.03	.53	12.60	1:6.0
Dora, ...	21.76	2.03	3.40	7.60	.57	13.60	1:6.0
Daisy, ...	21.76	2.03	3.40	7.60	.57	13.60	1:6.0
Linnie, ...	23.53	2.13	3.76	8.06	.58	14.53	1:6.2
May, ...	22.49	2.00	3.63	7.61	.54	13.78	1:6.2
Roda, ...	20.87	1.99	3.22	7.38	.56	13.15	1:6.0
Average, . .	22.33	2.07	3.51	7.74	.58	13.90	1:6.0

Average Daily Rations (Pounds).

Character of Rations.	Hay.	Silage.	Bran.	Corn Meal.	Flour Middlings.	Cotton-seed Meal.
Bran, ...	13.8	30.6	3.1	–	2.0	1.1
Silage, ...	12.6	30.0	–	2.5	2.0	1.5

Average Dry and Digestible Nutrients in Daily Rations (Pounds).

Character of Ration.	Dry Matter.	Digestible Organic Nutrients.				Nutritive Ratio.
		Protein.	Carbohydrates.	Fat.	Total.	
Bran, ...	23.55	2.16	11.22	.54	13.92	1:5.7
Silage, ...	22.33	2.07	11.25	.58	13.90	1:6.0

The average daily bran ration, consisting approximately of 14 pounds of hay, 31 pounds of silage (about a bushel), 3 pounds of bran, 2 pounds of flour middlings and 1 pound of cotton-seed meal, may be considered a good type of a dairy ration, and quite similar to combinations in use by many milk producers who buy all of their grain. It was the aim in preparing the silage ration to do away with the bran by substituting home-grown corn, and at the same time to produce a combination that would contain essentially the same quantity and proportion of digestible nutrients. This was accomplished by feeding 2.5 pounds of corn meal instead of 3 pounds of bran, and 1.5 pounds of cotton-seed meal in place of the 1 pound fed in the bran ration.

Assuming that the farmer produced the hay, silage and corn meal in the ration, he would only use 3.5 pounds daily of purchased grain, costing 4.7 cents, while the bran ration would require a daily cash outlay for grain of 7.25 cents.

The two rations contained almost identical quantities of digestible protein and of total digestible nutrients. Both rations appeared to be equally well relished by the animals. The entire herd consumed the bran ration without the least irregularity, while on the silage ration the cow May suffered an attack of indigestion which caused her to shrink noticeably in her milk, and rendered it necessary to reduce her feed for some ten days. Whether this disturbance may be attributed to the character of the ration, or to other causes, it is difficult to state with certainty. Cow Doliska, while receiving the silage ration, underwent an attack of mammitis in one quarter of the udder, which decreased her milk yield, and made it necessary to take away temporarily a considerable portion of her grain ration. This cow was producing a large yield of milk during the experiment, but was not in first-class physical condition. It seems probable that her condition rendered her sensitive to the combination of heavy grain, even though it was distributed through the silage.

Weight of Animals at Beginning and End of Experiment (Pounds).

Wheat Bran Ration.

	Blanche.	Brighty.	Doliska.	Dora.	Daisy.	Linnie.	May.	Roda.	Total Gain or Loss.
Beginning,	1,176	832	753	887	842	841	1,020	852	+29
End,	1,146	841	741	876	863	854	1,024	887	

Silage Ration.

	Blanche.	Brighty.	Doliska.	Dora.	Daisy.	Linnie.	May.	Roda.	Total Gain or Loss.
Beginning,	1,121	838	714	868	823	828	1,013	831	+18
End,	1,133	836	720	884	830	823	990	838	

The animals practically maintained their weight on each of the rations.

Yield of Milk and Milk Ingredients, with Percentage Gain or Loss (Pounds).

Wheat Bran Ration.

Cows.	Total Milk.	Daily Milk.	Total Solids.	Total Fat.	Butter Equivalent. ⅙ added.
Blanche,	1,004.08	23.91	145.19	51.51	60.10
Brighty,	790.62	18.82	122.39	49.73	58.02
Doliska,	1,105.37	26.32	134.97	40.24	46.95
Dora,	909.16	21.65	126.10	44.28	51.66
Daisy,	715.10	17.03	110.05	41.48	48.39
Linnie,	914.35	21.77	130.57	48.92	57.07
May,	834.73	19.87	123.54	43.99	51.32
Roda,	834.03	19.86	115.93	39.95	46.61
Totals,	7,107.44	21.15	1,008.74	360.10	420.12

Silage Ration.

Cows.	Total Milk.	Daily Milk.	Total Solids.	Total Fat.	Butter Equivalent. ⅙ added.
Blanche,	1,009.62	24.04	145.79	50.99	59.49
Brighty,	790.06	18.81	123.88	50.25	58.63
Doliska,	909.17	21.65	114.28	34.55	40.31
Dora,	874.78	20.83	125.01	44.44	51.85
Daisy,	798.06	19.00	123.14	46.13	53.82
Linnie,	997.35	23.75	141.82	52.86	61.67
May,	836.97	19.93	126.55	46.28	53.99
Roda,	930.92	22.16	126.42	43.19	50.39
Totals,	7,146.93	21.27	1,026.89	368.69	430.15
Percentage gain of silage over bran ration.	0.5	-	1.7	2.2	-

The yields are slightly in favor of the silage ration, but the differences are so small as to have no particular significance. Had cows May and Doliska remained undisturbed during the experiment, this increased yield would have been more pronounced.

Average Composition of Herd Milk (Per Cent.).

Character of Ration.	Total Solids.	Fat.	Solids not Fat.
Wheat bran,	14.19	5.07	9.12
Silage,	14.37	5.16	9.21

While the results show that the silage ration produced milk a trifle richer in both fat and solids not fat, the slight difference is without any important signification.

Dry and Digestible Matter required to produce Milk and Milk Ingredients (Pounds).

Character of Ration.	Dry Matter.			Digestible Matter.		
	One Hundred Pounds Milk.	One Pound Solids.	One Pound Fat.	One Hundred Pounds Milk.	One Pound Solids.	One Pound Fat.
Wheat bran,	111.35	7.85	21.98	65.84	4.64	13.00
Silage,	104.96	7.31	20.35	65.33	4.55	12.67

While the results show that in case of the silage ration it required a little less *dry matter* to produce a definite quantity of milk and butter fat, they also show that in case of both rations practically the *same quantity of digestible matter* was necessary to produce an equal quantity of milk products.

Food Cost of Milk Products.

Character of Ration.	Total Milk.	One Hundred Pounds Milk.	One Quart Milk (Cents).[1]	One Pound Butter (Cents)
Wheat bran,	$77 76	$1 09	2.45	18.5
Silage,	75 42	1 06	2.38	17.5
Percentage increased cost of bran over silage ration.	3.1	2.8	2.9	5.8

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[1] 2.25 pounds is the commercial figure allowed for one quart of milk; the theoretical quantity is 2.15 pounds, the excess of .10 of a pound being allowed for loss in handling.

With hay at $15 a ton, silage at $3.50, bran at $22, corn meal at $24, cotton-seed meal at $28 and middlings at $26, the silage ration produced milk and butter slightly cheaper than did the bran ration. This difference in cost is due partly to the temporary variation in the cost of the several grains, and partly to the slightly more favorable effect of the silage ration.

Approximate Fertilizer Ingredients in Rations (Cost).

Wheat Bran Ration.

172.29 pounds nitrogen, valued at	$30 15
134.92 pounds potash, valued at	5 40
68.04 pounds phosphoric acid, valued at	2 72
Total,	$38 27

Silage Ration.

169.99 pounds nitrogen, valued at	$29 69
119.77 pounds potash, valued at	4 79
54.88 pounds phosphoric acid, valued at	2 20
Total,	$36 68

The total rations consumed by the herd contained nearly the same quantity of plant food. There was a slight excess of potash and phosphoric acid in the bran ration, due to the richness of the bran in these two mineral constituents.

Conclusions.

1. The silage ration produced slightly more milk and milk ingredients at a trifle less cost than did the bran ration.

2. A little less dry and digestible matter was required to produce a given quantity of milk products with the former ration.

3. Two animals were temporarily out of condition while receiving the silage ration. This may have been partly due to the effects of the heavy concentrates and partly to other causes.

Discussion of Results.

1. In both experiments hay and corn silage served as the roughage, while a mixture of cotton-seed meal, flour middlings and bran, or cotton-seed meal, flour middlings and

corn meal or corn and cob meal, served as the two grain rations; bran acted as a diluter of the heavy concentrates in one case, and corn silage in the other.

2. In the first experiment the results were slightly favorable to the bran ration, while in the second experiment the conditions were reversed. The differences were so trifling that it may be said that for practical purposes both rations produced equally satisfactory results.

3. As a practical deduction, the writer would suggest that farmers who keep comparatively small herds, and who personally look after the feeding, may reduce the quantity of *purchased grain* to 3 or 4 pounds daily per head, and substitute home-grown corn in place of wheat bran. Five to 7 pounds of grain daily is the usual allowance for cows producing about 10 quarts of milk of average quality. This grain mixture may consist of 1½ pounds of cotton-seed meal, 2 pounds of flour middlings and 2½ to 3 pounds of corn or corn and cob meal daily; or 1½ pounds of cotton-seed meal, 2 pounds of oat middlings or rye feed and 2½ to 3 pounds of corn meal. Malt sprouts may be substituted for the wheat, oat or rye middlings. The several grains after being mixed should be distributed through the silage or cut hay with the aid of a fork. This method of feeding will enable the farmer to get along with a minimum *cash outlay* for grain (4½ cents daily), and at the same time he will be supplying a well-balanced ration, rich in elements of fertility. The method will be more particularly suited to farmers not having easy transportation facilities, and who sell their dairy products to the creamery.

4. Farmers and dairymen who cannot closely supervise the feeding, and who desire to feed more than 5 to 7 pounds of grain daily, will probably find it advisable to use one-third to one-half wheat bran in compounding the grain mixture. Distillers' grains and malt sprouts have also been shown to be quite satisfactory distributers of the heavy concentrates.[1]

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[1] Bulletin No. 94 of this station.

REPORT OF THE BOTANIST.

G. E. STONE; ASSISTANT, N. F. MONAHAN.

The long period of dry weather during the past summer has rendered many plants free from certain types of fungous diseases. On the other hand, the dry conditions were favorable for the outbreak of other troubles. A considerable amount of rain fell, and a more or less prolonged period of cloudy and damp weather prevailed during the latter part of August and first of September, which brought on some severe cases of blight. This rainy and damp period, coming as it did after the severe drought, exerted a peculiar influence on the quality of fruit, and in some instances it was responsible for inducing a renewed activity of the reproductive organs of plants. It is well known that favorable conditions following a check often stimulate vital activity along the lines of reproduction, and it was not surprising to find some wild plants responding in this manner.

Downy Mildew of Tomato.

(*Phytophthora infestans*, DBy.)

The damp and rainy period following the prolonged dry season caused an unusual outbreak on tomato plants, namely, the downy mildew, which is the same as that giving rise to the late blight of potatoes. It is seldom that this mildew attacks tomatoes, in this State at least, to any extent; but this season the damage was quite severe and widely disseminated, especially injuring the younger vegetative portions of the plants.

POTATO ROT.

(*Phytophthora infestans*, DBy.)

The fungus mentioned above was also responsible to a large extent for damage to potatoes, causing them to rot, especially those grown on moist land. During the early part of the season potatoes as a whole were remarkably free from blight, and not until the rainy and damp period came in September did they display any alarming troubles. In some instances quite a large percentage was destroyed by rot. The spraying of potatoes in this State has not met with that degree of success that it has in other New England States, one reason being that the early blight often occurs here quite disastrously, and obtains a foothold early in the season.

Spraying for this trouble should commence early in June, when the plants are about one-fourth grown, and continue until late in the season. Another factor underlying successful spraying is pressure ; at least 50 pounds' pressure should be maintained by the pump, to secure the best results. Experiments at the college this year showed material gain in the quantity of potatoes secured from sprayed crops, as compared with those not sprayed.

CUCUMBER AND MELON BLIGHT.

The dry summer with its freedom from moisture proved favorable for cucumbers and melons, and these crops were not severely affected, at least previous to September, with either the downy mildew or anthracnose. During the past fall there has occurred considerable infection to greenhouse crops, especially those started early. For the last six or seven years the downy mildew (*Plasmopara Cubensis* (B. & C.) Humphrey) has occurred generally upon greenhouse cucumbers started early in the house, and occasionally the anthracnose (*Colletotrichum Lagenarium* (Pass.) Ell. & Hals.) appears in the fall, but we know of no instances where either of these blights has wintered in greenhouses. Both of these blights must therefore at present be considered as left over from summer. The anthracnose, however, usually makes its appearance in the spring on greenhouse plants, and the mildew about the 15th of August on either outdoor or greenhouse crops. Both of these blights can be readily controlled in the greenhouse by judicious attention to cultural methods. Neither of them will survive if attention is given to light, ventilation and especially moisture. When the foliage is kept dry these fungi are unable to get a start. In case syringing is necessary to keep the red spider down, it should be done in the morning in bright sunlight, at which time the plants will dry out readily. In case these blights have attained some headway, the pipes should be painted with sulphur and oil. Beneficial results have been reported by different growers who have tried this method.

Sun Scald.

The general interest manifested in shade trees in this State is quite apparent from the large number of specimens sent us each year, and the amount of correspondence touching upon various matters concerning them. The number of cases of sun scald to shade trees the past summer was unprecedented. This was particularly noticeable in rock maples and white pines, although this same trouble occurred with many trees and shrubs to some extent. The sun scald on rock maples was unusually abundant, and more severe than usual. Some trees which were under our observation had as much as ninety per cent. of their foliage as dry and crisp as casted leaves. Some maple trees possess the peculiarity of having their leaves badly scorched each year, where other trees of the same species located near them are entirely free from this trouble.

As a result of the prolonged drought and the excessive heat during mid-summer, many rock maples developed foliage of a peculiar bronze color. There was also much premature fall coloring and defoliation on many trees. The cause of so much sun scald during the past summer was drought and dry winds.

Where fine specimens of lawn or roadside trees exist, every effort should be made to maintain them in the best condition possible. A deep, rich, loamy soil, well supplied with organic matter, constitutes a good guarantee against sun scald.

BURNING OF CONIFERS AND EVERGREENS.

The burning or drying up of leaves commonly seen on conifers and other evergreens in spring is the result of winter or spring injury. Trees affected in this manner show the burning generally on one side, which coincides with the direction of some prevailing wind or storm. This is a genuine scald, similar to that prevailing on other trees, and occurs at a time when the ground is frozen and drying winds prevail. This is usually brought about by a sudden rise of temperature in the early spring when the plants are in frozen ground, at which time transpiration is active. Under these conditions root absorption is limited, whether the soil is moist or dry, and burning results.

An arbor vitæ hedge, which has been under our observation for some years, located on high ground with a severe exposure, becomes burned more or less every year. Frequently the burning is on the southeast side and occasionally on the southwest, but more often on the northwest, which is the direction of the prevailing winds.

There is a considerable amount of burning to conifers and rhododendrons in this State, and not infrequently this is so bad that the specimens are ruined. Much of this injury occurred during the winter of 1904–05, on evergreens located on private estates and in nurseries. One nurseryman states, for example, that all his evergreens, which included various species of abies, buxus, chamæcyparis, juniperus, picea, pseudotsuga, taxus, thuya and tsuga, burned last winter, and other nurserymen have experienced trouble with retinosporas and varieties of thuya or arbor vitæ.

Our native conifers are seldom injured in this manner except when transplanted in some uncongenial place, or where the environment is more or less modified. Swamp cedar burns frequently when taken from the swamp and grown in ordinary soil, and the arbor vitæ, sparingly found as a native in this State, frequently burns when planted on high or more or less dry land with severe exposure. This holds good also for hemlocks, and to a certain extent for pines and junipers.

WINTER-KILLING.

The disastrous effects of winter-killing are probably more discernible in the State at the present time than for many years; at least, we have no recollection of seeing so much damage done to so large a variety of trees and shrubs as has occurred in the last two or three years. The winter of 1903–04 was extremely severe on most of the native and exotic plants, including trees, shrubs and vines; and, while the winter of 1904–05 was not so severe in many ways, the past summer has done much to emphasize any trouble that was present to a slight degree before. The winter of 1902–03 was also a severe one, although the effects of killing during that period were largely above ground.

The symptoms of winter-killing are tolerably well marked in most instances, especially to the trained observer, and it is seldom that it need be confounded with anything else, neither is it always necessary to make extensive examinations of root systems to ascertain root killing. Furthermore, because a plant is native constitutes no evidence of its ability to withstand unusually severe conditions, since unusual seasonal peculiarities often render them less hardy. For example, the Labrador tea, which is a native of Labrador, has been known to winter-kill in this State, although the climatic conditions of this State are decidedly milder than those of Labrador. There are several classes of winter injury which may readily be distinguished, some of which are not unusual, and can be found every year. There is killing of that portion of the plant above ground as well as killing of the root systems, the latter being extremely common during the winter of 1903–04. Besides these types of injury mentioned above, there frequently occur frost cracks, twig killing, bud injuries, blisters to leaves, etc. The latter has occurred occasionally in leaves of apple trees in the spring when they were tender, and frequently results in almost complete defoliation of apple trees during August. This trouble has been studied by Sorauer in Germany, by Stewart in New York, and by Stone and Smith in this State.

Some of the conditions which underlie winter-killing are as follows: —

Severe cold, causing frost to penetrate to a great depth.

Sudden and severe cold following a prolonged warm spell in the fall, in which case the wood tissue is tender and immature.

Conditions which favor a soft growth and immaturity of wood. Various causes may be responsible for this, such as growth in a low, moist soil, too heavy manuring or fertilization, or absence of sufficient sunlight.

General low vitality, caused by insect pests and fungous diseases and lack of moisture in the soil.

Insufficient soil covering, such as lack of organic matter, light mulching and snow covering in winter.

Location in unusually windy and exposed places, etc.

Species with a limited maximum range for cold are especially susceptible. There are innumerable examples at hand which will furnish illustrations of the various causes of winter-killing. For example, low vitality is well illustrated by the large number of old apple trees which have died in the last two years. The old, neglected orchards were the worst sufferers from the effects of winter-killing, and many isolated trees, such as cherry trees that had received no care for some years, were badly affected.

In one instance a number of peach trees and various kinds of shrubbery, both native and exotic, were severely injured where located near an overflow from a cesspool, while similar shrubbery near by was not injured in the least. This injury was due to the more rapid and tender growth of those plants which received benefit from the cesspool overflow. Perfectly hardy native plants, being deprived of a normal amount of light or grown in too dry places, are winter-killed readily; and Japanese maples on high, dry ground with severe exposure are extremely subject to winter-killing.

By far the most noticeable effects of winter-killing have occurred above ground. This in some cases has resulted in local injuries to the trunk or in the loss of a few limbs, which has been responsible for completely ruining the symmetry of many valuable specimens, while in other instances many plants have died back to the ground. Some of the plants which have been affected in this way are as follows: Japanese maples, sycamore and Norway maples, apple, peach, plum, cherry, quince, grape vines, Japanese clematis, matrimony vine, roses, Forsythias, California privet, Amorpha fruticosa, Callicarpa purpurea and Americana, Ampelopsis tricuspidata, Deutzia scabra and gracilis, Diervilla florida-candida, Catalpa bungei, Exochorda grandiflora, Hibiscus syriacus, Magnolia tripetala, Lonicera japonica-halliana, Stephanandra flexuosa, Viburnum tomentosum, Tamarix tetrandra, Rhus semialata and Æsculus pavia.

Among the native plants may be mentioned the pine, ash, oak, white birch, alder, spice bush and holly. We observed large clumps of white birch and alders winter-killed above ground. The winter-killing of branches and twigs often occurs on young Japanese maples, especially where exposure is severe or when not given the best cultural conditions; and the young twigs of Norway and sycamore maples and horse-chestnuts have been quite susceptible to winter-killing of late. The killing of the buds and wood occurred in forsythias, peach and roses. Much of this winter-killing of branches, etc., is generally followed by an outbreak of Nectria cinnabarina and Schizophyllum.

As previously stated, the winter of 1903–04 was extremely severe in the amount of root killing which took place. The trees showing injury were the apple, pear, peach, quince, cherry, plum, white pine, red and rock maples, butternut, ash, oak and elm. Among shrubs, vines, etc., were the grape, raspberry and blackberry.

Many of the exotic ornamental plants suffered in the same way, such as, for example, the deutzias, California privet, etc.; in fact, many of the native and exotic species showed killing both above and below ground. The trees which have shown root killing the worst are apples, red maples, butternuts and pines. The effects of the winter-killing of roots manifest themselves in many ways. Sometimes the plant is killed outright, while in other instances only a slight injury is caused. Many maples, for example, were killed outright, while others lost only a certain per cent. of their roots, thus causing thin tops, and where this injury was not very extensive many of the thin-top trees recovered in one year.

In some instances the leaves at the top of the red maple remained in a half-developed condition throughout the summer. In such cases the leaves were rather pale in color, and they assumed a peculiar pendulent position on the branches. These trees have also for the past two years manifested a premature autumnal coloration, especially on those portions with poorly developed foliage, the result of a limited water supply caused by winter-killing of the roots.

Apple trees were affected to a large extent by root killing, and many hundreds of them have succumbed. In many cases these trees would have been saved if severe pruning had been practised at the time of the first appearance of this trouble, since severe pruning of the tops of the trees would have balanced the root and branch systems. Peach, plum and quince trees were affected in the same way, but the trouble was not nearly so general with these. The same holds true for blackberries, raspberries and grapes. One of the peculiarities displayed by many of these plants consisted in their leaving out and bearing fruit, then suddenly collapsing.

The white pine was the most extensively affected tree. These trees in some localities were so severely affected that many of them died during the spring following the winter of 1903–04. In some severe cases the trunks were frozen and badly injured, but in the greater majority of cases the tips of the new leaves became brown and died. The dry summer of 1905 was severely trying for these partially affected pines. Had a normal water supply been available, this injury would not have resulted. The specimens which we examined had a large percentage of the small, fibrous roots killed, but in no case observed had the large roots been injured. This pine injury extends throughout the whole State, but appears to be less common in the Connecticut valley than elsewhere.

One of the most distinctive features connected with the pine during the past summer was the burning of the tips of the leaves. In most cases the young, new leaves commenced to turn yellow at their ends, as if sun scorched, but usually grew worse; and in many instances all the needles turned yellow, subsequently died and dropped off. This might not occur on the whole tree, but on only one or more branches. Occasionally this trouble would occur before the young needles reached their normal length; and in such cases the needles would be short and the tree would present a stunted foliage, as we sometimes see on pines grown in very dry soil. Many were inclined to believe that some fungous disease was affecting the pines. Our examinations of the young needles in early summer showed no indications of fungi being present, and others have reported the same results. Subsequently, however, there appeared various species of fungi on the leaves, and in some cases on the branches, etc. This was merely a natural result following the weakened condition of the tree, caused by the affected root system.

Mrs. Flora W. Patterson of the Department of Agriculture in Washington, who had exceptional opportunities to examine the pine trouble as it occurred in New England and elsewhere during the summer, reports at least six different species of fungi upon the needles and branches. From examination of considerable material gathered in this State she has reported having found Phoma Harknessii, Sacc., Septoria parasitica, Hartig, Hendersonia foliicala, Berk. The Septoria was found in connection with the leaves that had their tips burned, and the Hendersonia was associated with a general yellowing or irregular spotting of the needles, while the Phoma was found with a quite different and by no means common trouble, causing no serious injury to the trees.

In conclusion, we would state that the trouble affecting the pine in this State was due primarily to the extreme winter-killing of the roots during the winter of 1903–04, together with the unusually severe drought occurring in the summer of 1905. The occurrence of so many different fungi on the pine, which especially predominated during the late summer and fall, was very largely a secondary result of the weakened condition of the tree caused by winter-killing.

Relation between Soil Aeration and Germination and Growth.

For some time our attention has been given to the relation existing between seed germination and plant development, and soil texture and aeration. This problem possesses a practical bearing, inasmuch as it underlies the question of soil selection for specific crops. It is not our purpose at present to go extensively into this subject, but only to touch upon one phase of it. It is well known to gardeners and others that aeration, or the presence of air in soils, plays quite an important role in the development of seedlings. This experiment was made to determine what effects forcing air through soil would have upon germination and growth. For this purpose we made use of loam placed in two boxes, 18 by 18 by 18 inches. In each box there was a round funnel, 4½ inches in diameter, buried under the soil 1½ inches from the surface. Both funnels were connected with block tin tubes leading outside of the box, one of which was attached for a period of six hours each day to a water blower, and the other remained unconnected. Lettuce seed, which is quite susceptible to aeration, was employed, and 1,500 seeds were placed in each box, and the necessary data pertaining to germination, etc., were noted.

Table showing Results of Aeration on Growth of Lettuce Seedlings. 1,500 Seeds in Each Box.

	Number of Plants obtained.	Weight of Seedlings (Grams).		Average Gain in Weight (Per Cent.).
		Total.	Average.	
Unaerated, ...	977	83	.0847	–
Aerated, ...	1,210	152	.1239	46.27

From the preceding table it will be noted that there was considerable more seed germinated in the aerated box than in the unaerated one, as noted by the number of plants obtained; and that the average weight of the seedlings in the aerated exceeded those in the unaerated by 46 per cent. The seeds in the aerated box showed decided acceleration in germination, there being a difference of at least thirty-six hours in favor of the aerated seed. This experiment lasted from October 5 to November 8, and the difference in the size of the plants became more marked each day. In the aerated box the plants were noticeably larger over the funnel, while in the unaerated box the plants were largest near the edges of the box, where the soil had shrunk away from the sides, which enabled the roots of the seedlings to have free access to air.

That oxygen plays an important part in the germination of lettuce seed is quite evident from many experiments we have made with this species. The mere fact of covering lettuce seed loosely or sifting fine loam on them results frequently in enormous differences in the germination. Such seeds as lettuce and white clover are particularly susceptible to aeration; and, according to our numerous experiments, these seeds germinate best in soils of loose texture.

Comparison of Sterilized Loam and Subsoil.

Some experiments were conducted two years ago by Mr. S. R. Parker, then a senior specialist in the agricultural department of the college, which necessitated using a sterilized soil. In all of Mr. Parker's cultures, which were made in a soil very poor in organic matter, there was an extremely poor and sickly growth of soy bean in those pots which had been sterilized, whereas the growth was good in pots which had not been steamed. The experiments were carried on in our greenhouse, and the results were so different from those occurring in sterilized loam that it was considered wise to repeat them.

A soil similar to this had previously been sterilized for the growth of tobacco seedlings, without producing similar disastrous effects upon the plants. In the single experiment given here we made use of a similar soil, namely, a yellow subsoil loam, containing little organic matter. Eight pots were selected, four of which contained loam and four subsoil. Of these, two each of the loam and subsoil pots were sterilized, and two each of the remaining pots were left unsterilized. The results follow.

Table showing Growth of Soy Bean in Sterilized and Unsterilized Loam and Subsoil.

	Total Number of Pots used.	Average Length (cm.) of Stems in —		Gain (+) or Loss (—) in Sterilized Soil (Per Cent.).
		Unsterilized Soil.	Sterilized Soil.	
Loam, ...	4	9.53	10.87	+14.05
Subsoil, ...	4	9.79	4.14	—57.70

The number of seeds germinated in unsterilized loam and soil was 30, that for the sterilized 34, showing a slight gain in favor of sterilization, which is unimportant, considering the small number of seeds used. There is also a gain in height of loam plants of 14 per cent. in favor of sterilization, while in the subsoil series there is a loss of 57 per cent. due to treatment. The subsoil pots also showed a poor, sickly development. This corresponded in every way with the results obtained by Mr. Parker in his experiments. This experiment shows, among other things, that extreme precaution is necessary in drawing deductions from experiments in which the soil is sterilized, especially where inoculation work is undertaken in connection with soil organisms.

Influence of Soil Sterilization on Seed Germination.

In a previous report [1] the results of a similar series of experiments were described, and this paper is a continuation of the earlier one. As in the preceding series, the seeds selected were in most cases from an old lot, which possessed a rather low germinating capacity. The object of these experiments was to ascertain the degree of acceleration in germination which would result from plant seed in sterilized soil. Results of a similar nature have been observed by us a number of times in an incidental way when utilizing sterilized soils in our general experimental work in the greenhouse. The seeds were planted in boxes 18 by 12 by 3 inches, and previous to planting the soil in the sterilized boxes was heated by steam to a temperature of about 212° F. for one hour. The soil used constituted a good typical loam, characteristic of this region, and the sterilized and unsterilized soils were identical in every way except as to steaming. Other conditions, such as heat, light, degree of moisture, etc., were made the same as far as practicable. In Nos. 15 to 23, inclusive, 600 seeds were used in three separate experiments, where 100 seeds were sown in sterilized soil and 100 in unsterilized soil. In Nos. 25 to 34, inclusive, 800 seeds each were employed, there being two experiments. No. 39 is the result of only one experi-

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[1] Fifteenth annual report of the Hatch Experiment Station, p. 41, 1903.

Table showing the Germination of Seeds in Sterilized and Unsterilized Soil.

Laboratory Number.	Kind of Seed.	Total Number of Seeds tested.	Number Germinated in —		Per Cent. gained.
			Sterilized Soil.	Unsterilized Soil.	
15,	Turnip,	600	159	54	35.00
16,	Radish,	600	148	101	15.66
17,	Onion,	600	148	94	18.00
18,	Red clover,	600	236	203	11.00
19,	Lettuce,	600	289	267	7.33
20,	Musk melon,	600	–	–	–
21,	Lettuce,	600	208	51	52.33
22,	Tomato,	600	79	63	5.33
23,	Crimson clover,	600	15	4	3.66
25,	Melilotus,	800	133	109	5.75
26,	Spinach,	800	378	246	33.00
27,	Peppergrass,	800	233	106	31.75
29,	Japanese millet,	800	–	–	–
32,	White mustard,	800	242	65	44.25
33,	White carrot,	800	–	–	–
34,	Winter vetch,	800	30	8	5.50
39,	Soy bean,	1,000	365	175	38.00
Average,		–	–	–	21.89

ment, this being made in the greenhouse bench soil; 500 seeds were sown in unsterilized soil and 500 in sterilized soil.

The data given in the table show that there occurred a positive gain in germination of the seed sown in sterilized soil. Nos. 20, 29 and 33, however, were old seed, which had apparently lost their power of germinating, and the stimulating effect induced by soil sterilization evidently had no effect on them. There is no reason for believing that when seeds have once lost their germinating power, or, in other words, are dead, this process will revive them. The percentage gained in some instances is quite marked, while in others it is insignificant. The average obtained from this series is 21 per cent. On account of the low germinating capacity prevailing here in many instances, the percentage gained is only indicative, since it would be necessary to employ a larger number of seeds to obtain more accurate averages. It should be pointed out, however, that better results than those given in these experiments have been observed many times in connection with lettuce, cucumber, melon seed, etc., in the greenhouse, where seed was used on a much larger scale. The degree of acceleration in germination is also marked, a feature which has been frequently noticed by us before. The number of seeds germinated during the first few days of these experiments, including Nos. 15 to 34, inclusive, was 169 for the sterilized soil and 146 for the normal loam, or a gain of 14 per cent. in favor of the sterilized soil. In the former series of experiments, previously noted, we obtained 25 per cent. of acceleration at the end of four days. There undoubtedly exists a difference in seeds in their response to stimulation in sterilized soils. Tomatoes, for example, respond but little if any to this method of treatment. The cause of this variation in different species of seeds is not known. Experiments are now being made along different lines which may throw some light on this question. The benefit to be derived from sowing seed in sterilized soil, both from a physiological and pathological point of view, is important enough to warrant in many instances its practice.

INFLUENCE OF SOIL DECOCTIONS ON SEED GERMINATION.

Some attempt has been made in the following experiments to ascertain the cause underlying the effects which sterilized soil has on seed germination. The question has often arisen, In what manner does soil sterilizing affect seed germination? Is the cause underlying this form of stimulation a mechanical one, or a chemical one? In all probability both mechanical and chemical factors play a role here. If, however, the stimulus is of a chemical nature (and such types of stimulation are common enough to seeds), we would expect some response to occur on the part of the seeds when treated with decoctions of sterilized soils. For special reasons we therefore selected two types of soils, one of which was a typical Amherst loam, fairly rich in organic matter and suitable for greenhouse culture; the other soil a yellow loam of the nature of an Amherst subsoil, deficient in nitrogen and containing only a slight amount of organic matter. Three sets of experiments were carried out with each soil. In each set there was a boiled loam and subsoil, a sterilized loam and subsoil, and a normal loam and subsoil. The boiling and sterilizing lasted fifteen minutes, the latter being mostly done in an autoclave, under fifteen pounds pressure and at a temperature of 250° F. In all cases 400 grams of soil were employed. The soils were placed in percolators, with 500 c.c. of distilled water, and allowed to stand for twelve hours and to percolate very slowly. Four hundred grams of normal loam and subsoil, that is, soil that is not treated, were percolated in the same manner as the others. In addition to the above tests, tap water cultures were employed as checks, and run parallel in every way to the others.

In some instances, however, distilled water was used, besides the tap water, but since no difference existed between them, the distilled water tests were discontinued. After a percolate had been obtained for the various soils, the seeds were soaked in them for six hours, and then placed in germinators of the Zurich type, or into germinators composed of flower pot saucers provided with filter paper. In one or two instances the soy bean was germinated in sawdust.

TABLE I. — *Showing the Influence of Soil Decoctions upon Germination of Seeds immersed for Six Hours in Decoctions made by percolating 500 c.c. of Water through 400 Grams of Soil; 800 Seeds used in Each Treatment, except with the Soy Bean, where only 700 were used, making a Total of 21,700 Seeds.*

SEED.	PERCENTAGE OF GERMINATION IN —						
	Tap Water.	Normal Loam.	Normal Subsoil.	Boiled Loam.	Boiled Subsoil.	Sterilized Loam.	Sterilized Subsoil.
Soy bean,	28.3	25.5	33.0	33.9	34.9	18.6	32.6
Buckwheat,	59.8	72.0	70.7	69.5	70.8	53.5	73.1
Radish,	52.7	51.7	53.1	51.8	56.7	48.5	52.3
Lettuce,	70.2	82.3	71.8	80.7	77.6	71.6	61.8
Average,	52.7	57.8	57.1	58.9	60.0	48.0	54.9
Total average,	52.7	57.4		59.4		51.5	

The preceding table shows the results obtained from experiments in which 21,700 seeds were employed. Since a large number of seeds were used in these experiments, quite accurate averages were obtained, and the factors due to variation are eliminated to a large extent. There is apparently a slight gain due to treatment shown in these experiments. The best average results were given by the boiled subsoil and loam, followed by the normal, while the sterilized loam is below the tap water seeds. By noting carefully the results obtained in these experiments, together with the nature and color of the decoctions, we surmised that the decoctions were too strong for the best results, consequently they were diluted with water to one-half strength in the next experiment.

TABLE II. — *Showing the Influence of Soil Decoctions upon Germination of Seeds immersed for Six Hours in Decoctions made by percolating 500 c.c. of Water through 400 Grams of Soil, diluted to Half Strength; 600 Seeds used in Each Treatment, making a Total of 16,800 Seeds.*

SEED.	PERCENTAGE OF GERMINATION IN —						
	Tap Water.	Normal Loam.	Normal Subsoil.	Boiled Loam.	Boiled Subsoil.	Sterilized Loam.	Sterilized Subsoil.
Soy bean, . .	50.0	50.2	51.0	55.5	53.5	55.2	51.7
Buckwheat, . .	77.2	70.5	81.2	82.5	83.5	72.5	73.0
Radish, . . .	48.0	53.2	48.0	59.7	53.0	60.5	58.5
Lettuce, . . .	82.2	83.7	87.2	78.0	73.7	74.0	80.8
Average, . .	64.3	64.4	66.8	68.9	65.9	65.5	66.0
Total average,	64.3	65.6		67.4		65.7	

These experiments are similar to the previous ones, except that half-strength decoctions were used in all cases. The results obtained from these three experiments are remarkably uniform in character, the tap water giving practically the same results as the decoctions.

TABLE III. — *Showing the Influence of Soil Decoctions upon Germination of Seeds immersed for Six Hours in Decoctions made by percolating 500 c.c. of Water through 400 Grams of Soil, diluted to One-fourth Strength; 600 Seeds used with Radish and Buckwheat, 400 Seeds with Lettuce and Soy Bean, making a Total of 14,000 Seeds.*

SEED.	PERCENTAGE OF GERMINATION IN —						
	Tap Water.	Normal Loam.	Normal Subsoil.	Boiled Loam.	Boiled Subsoil.	Sterilized Loam.	Sterilized Subsoil.
Soy bean, .	84.0	74.5	89.5	73.0	83.5	77.5	84.0
Buckwheat, . .	66.5	91.7	85.0	93.7	91.7	82.7	83.7
Radish, . . .	65.5	64.5	62.5	46.5	50.0	55.5	56.5
Lettuce, . . .	74.5	72.7	72.7	63.7	70.7	65.2	69.5
Average, . .	72.6	75.8	77.4	69.2	73.9	70.2	73.4
Total average,	72.6	76.6		71.5		71.8	

In the experiment with the one-fourth strength decoctions, 14,000 seeds were employed, representing three experiments. There is a slight increase shown in this series, due to treatment, which is the most marked in the normal loam and subsoil.

TABLE IV. — *Showing the Influence of Soil Decoctions upon Germination of Seeds immersed for Six Hours in Decoctions made by percolating 500 c.c. of Water through 400 Grams of Soil, diluted to One-eighth Strength; 200 Seeds used in Each Treatment, making a Total of 5,600 Seeds.*

SEED.	PERCENTAGE OF GERMINATION IN —						
	Tap Water.	Normal Loam.	Normal Subsoil.	Boiled Loam.	Boiled Subsoil.	Sterilized Loam.	Sterilized Subsoil.
Soy bean, . .	75.5	75.0	75.5	85.5	85.0	87.0	80.5
Buckwheat, . .	66.5	82.0	83.0	84.5	81.5	78.5	83.5
Radish, . . .	55.0	70.0	69.0	77.5	81.5	78.5	72.0
Lettuce, . . .	70.0	68.5	74.5	98.9	73.0	77.0	79.5
Average, . .	66.7	73.8	75.5	86.6	80.2	80.2	78.8
Total average,	66.7	74.6		83.4		79.4	

The experiment with one-eighth strength decoction shows a decided gain throughout in the treated seeds, the most marked being given by the boiled and sterilized loams and subsoil decoctions. No further dilutions were tried, but from a careful study of the results of these experiments we are inclined to the belief that if more dilute solutions were used an increased gain would occur, especially in the sterilized series, since the most highly colored decoctions were obtained from the sterilized soils and the next highest color from the boiled soils. It appears to us that the sterilized decoctions were too strong, even when diluted to one-eighth strength. Some variation in the strength of the decoctions is likely to occur as a result of different percolators, and the failure of the one-fourth and one-half strength to show more of an acceleration may be attributed to this cause.

The following table gives the number of seeds that germinated in the first twenty-four hours in the preceding experiments, including tables I., II., III. and IV., from which the degrees of acceleration and retardation due to treatment can be obtained.

TABLE V. — *Showing the Degree of Retardation and Acceleration in Germination of Seeds soaked for Six Hours in Decoctions of Different Strengths made by diluting 500 c.c. of Water which had percolated through 400 Grams of Soil treated as below.*

	Number of Seeds per Treatment.	PER CENT. GERMINATED IN TWENTY-FOURS HOURS IN —						
		Tap Water.	Normal Loam.	Normal Subsoil.	Boiled Loam.	Boiled Subsoil.	Sterilized Loam.	Sterilized Subsoil.
Soy Bean.								
Full strength, . .	600	27.7	27.5	30.5	33.1	29.5	8.3	27.5
Half strength, . .	200	22.0	20.0	17.0	21.0	23.0	23.0	23.5
Buckwheat.								
Full strength, . .	600	56.0	70.1	73.6	63.1	66.6	33.8	70.8
Half strength, . .	400	55.0	44.2	57.5	57.2	31.7	36.7	46.2
Quarter strength, .	400	43.7	59.5	50.2	57.2	59.0	52.7	64.5
Eighth strength, .	200	58.5	70.0	66.0	78.0	74.5	62.0	62.5
Radish.								
Full strength, . .	800	36.7	27.0	29.8	30.5	37.5	16.6	32.0
Half strength, . .	400	28.0	37.5	30.2	41.7	37.5	43.0	32.2
Quarter strength, .	400	45.0	43.5	39.0	17.5	24.0	37.0	37.0
Eighth strength, .	200	32.5	64.5	61.5	68.0	73.0	69.5	61.0
Lettuce.								
Full strength, . .	800	37.5	35.8	39.3	34.5	41.5	37.3	35.1
Half strength, . .	400	59.0	72.5	63.2	74.0	46.0	50.2	70.7
Quarter strength, .	400	67.0	52.0	55.7	44.5	51.5	53.5	56.5
Eighth strength, .	200	51.0	55.0	55.0	83.0	52.0	72.0	64.5
Average, . .	–	41.8	45.3	44.7	47.3	43.7	39.1	45.9
Average normal and total treated.	–	41.8	45.0		45.5		42.5	
		41.8	44.3					

This table gives the results of germination during the first twenty-four hours of 42,000 seeds, and the degree of acceleration obtained corresponds in a general way with the total number germinated as given in the preceding tables; or, in other words, the relationship between acceleration and the total number of seeds germinated is similar. Comparing the average number of seeds germinated during the first twenty-four hours by the various treatments with tap water, there are no important differences shown. On the whole, however, there is a gain or acceleration due to treatment, the maximum acceleration being shown by the boiled loam.

A comparison of the different strengths of solutions shows that the one-eighth dilution produced the best results of any of the treatments, that for boiled loam being the highest. This series of experiments shows that decoctions of soils variously treated induce acceleration in seed germination, and that a larger number of seeds germinated in decoctions than in tap water. This increase is quite marked in dilute decoctions (one-eighth strength), and would probably be increased to some extent if the dilution should be carried still further. In these experiments we have a chemical explanation for the cause underlying acceleration and increased germinating capacity in sterilized soils. Undoubtedly driving out the gases and the subsequent absorption and renewal of fresh oxygen in sterilizing practices acts beneficially to soil and induces the seeds to germinate more quickly, as is shown by the aerating experiments previously reported. By the process of aeration, or by soaking seeds in dilute decoctions, many seeds germinate that otherwise would not; but there is no ground for belief that any of these stimulating processes actually revive or rejuvenate worthless seeds to a greater extent than would result from the most favorable conditions for germination.

Sterilized subsoil, or that lacking in humus, has the same effect on germination as sterilized loam rich in organic matter; but it inhibits growth to a very large extent, thereby differing in this respect. It would appear, therefore, that a considerable amount of humus is necessary in soils, in order that they may be materially benefited by sterilization.

The reason that bacteria multiply more and plants grow much more luxuriantly in sterilized soils is undoubtedly due to the fact that a larger amount of available material for plant development is present. Why subsoils and those poor in organic matter give rise to a greatly inhibited growth is not so clear at present, and we are not prepared to offer any explanation of this phenomenon.

SEED SELECTION.

It is a well-known fact that heavy, well-developed seeds produce more vigorous and more productive plants than lighter seeds of the same variety. This is altogether a reasonable statement, because the heavy, well-filled seed has the more perfect embryo, and also has the larger supply of plant food on which to support the seedling until the plant is capable of getting its nourishment from the air and soil.

With such crops as wheat, rye and the grasses, the selection of seed is not of so very great importance, because usually an overabundance of seeds is planted, and sufficient seeds develop so that in the natural struggle for existence in their overcrowded state the weaker and less vigorous plants are crowded out and only the more vigorous and healthy plants reach maturity ; and this number which reaches maturity represents the maximum number of plants that can be developed under existing conditions, so that nothing in the crop is lost by this crowding out of the weaker plants. On the other hand, with greenhouse, market gardening and general field or what is known as hoed crops, the conditions are entirely different. In this case each plant has its full share of light, heat and space, and a poor, weakly plant is just so much loss, not only because it occupies a space that ought to produce a well-developed plant, but also because a number of undersized, weakly plants in a crop detracts from the market value of the crop as a whole, and also because weak plants are more subject to disease, and act as a breeding-place for diseases that may infect the whole crop ; therefore, the careful selection of seed becomes an important factor in growing plants. In the case of large seeds, such as corn, this selection is comparatively an easy matter. An ear of corn of the desired type, having kernels of a desirable size and shape and of full development, may be picked out, and by discarding the poor, undeveloped seeds at either end the rest of the seeds may be utilized for planting. Here knowledge of the type of seed and judgment only may be relied upon. Beans, peas, etc., may be selected in much the same way, with reasonable assurance that the best results will be obtained. In the case of such seeds as lettuce, turnip, cabbage, tobacco and other small seeds this method of separation is not practicable, and other methods have to be resorted to.

From early times the separation of seeds by means of water has been practised to a considerable extent. In this case the seed is placed in a quantity of water, well shaken and let stand a few minutes, then the seeds which do not sink are removed, and only those that have sunk used for planting.

The results of some of our experiments with this method of separation are given in the tables following.

TABLE I. — *Showing the Results of Germination with Onion and Lettuce Seed separated by the Water Method; 400 Seeds used in Each, or a Total of 1,600.*

SEED.	PER CENT. GERMINATED OF —		Per Cent. Increase of Germination of Heavy over Light.
	Light.	Heavy.	
Onion, ...	38.0	85.0	142.5
Onion, ...	50.0	58.5	17.0
Onion, ...	44.0	88.0	100.0
Lettuce, ...	68.0	90.0	32.3

TABLE II. — *Showing the Results of Seed Germination and Growth of Onion Seedlings separated by Water; 200 Seeds in Each Lot, or a Total of 400 used.*

ONION.	Per Cent. of Germination.	Number of Plants.	WEIGHT OF PLANTS (GRAMS).		Average Per Cent. gained of Heavy over Light.
			Total.	Average.	
Heavy (sank), . . .	42.5	85	18.1	.213	37.42
Light (floated), . . .	19.5	38	5.9	.155	-

This method, however, is not entirely satisfactory, because many of the heavier seeds are buoyed up by air bubbles and therefore thrown away, and in our work we have noticed that a few of the undersized seeds also go to the bottom.

Many investigators[1] have carried this process still farther, and separated their seeds by what is known as the specific gravity method. In this case solutions of salt (sodium chloride), ammonium nitrate, sodium nitrate, potassium nitrate and calcium chloride have been used. For this purpose solutions of different specific gravities have been made, in which the seeds were placed, first in that solution with the highest specific gravity. The seeds which floated in this solution were skimmed off and placed in that of the next highest specific gravity, and so on. It has been found that by this method seeds of the same variety, of a uniform, sound condition, differ in specific gravities only within a very narrow range. This, however, does not seem to be a very practical plan, as it involves the making of solutions of tested specific gravity and quite a little mechanical manipulation. Another method, known as the specific gravity sampling method, is perhaps of less value, as in this case one lot of seed is compared with others in bulk, without separating the poor and undeveloped seeds. It amounts simply to the choosing of the best lot from several samples of seeds.

The separation of seeds by sieves would seem to be the easiest and most practical way, and this method with us has given very good results. We used a series of four sieves, having round perforations of 2 mm., 1.5 mm., 1 mm., and .05 mm. respectively. Ten grams of seed were weighed out and run through this series of sieves, with the following results : —

TABLE III. — *Showing the Results of sifting Seeds, in which 10 Grams were employed.*

NUMBER OF SIEVE.	Size of Seed.	Weight in 10 Grams of Seed (Grams).	Per Cent.
No. 1, ...	2.0-1.5 mm.	1.015	10.15
No. 2, ...	1.5-1.0 mm.	6.689	66.88
No. 3, ...	1.0- .5 mm.	1.800	18.00
No. 4, ...	.5- .0 mm.	0.491	4.91

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[1] Among whom may be noted V. A. Clarke, New York (Geneva) Experiment Station, Bulletin No. 256.

Five hundred seeds were then counted out from each of these four grades or sizes of seeds, with the exception of No. 4 (.5–.0 mm.), which was composed entirely of chaff, dirt, etc. These were sown in flats and allowed to grow for four weeks, when the seedlings were taken up, counted and weighed, with the following results: —

TABLE IV. — *Showing the Results of Germination and Growth of Seedlings from Three Experiments with Sifted Lettuce Seed; 1,500 Seeds used in Each Experiment, making a Total of 4,500 Seeds employed.*

SIZE OF SEED.	Per Cent. germinated.	Number of Seedlings.	WEIGHT OF SEEDLINGS (GRAMS).		Average Per Cent. gained in Weight of Large over Small Seedlings.
			Total.	Average.	
2.0–1.5 mm., . . .	56.7	672	347.5	.518	98.42
1.5–1.0 mm., . . .	53.5	642	293.7	.457	75.09
1.0– .5 mm., . . .	40.4	485	126.3	.261	–

From this table it will be seen that of the large 16.3 per cent. and of the medium 13.1 per cent. more seeds germinated than of the small seeds, and that the four-weeks-old seedlings from the large seed averaged 98.42 per cent. and those from the medium seed 75.09 per cent. heavier than those from the small seed. It will also be noticed that the differences in the per cent. of germination and the weight of seedlings from the large and medium seeds were not very great; but the difference between the germination, and especially in the weight of seedlings of the larger and small seeds, is very marked.

We are of the opinion that it would pay a grower to separate his lettuce seed with a sieve having a mesh of one millimeter in diameter (1/25 inches), and to use only such seed as did not pass through a sieve of this size. From these plants he could make a further selection, as is customary at the time of transplanting. This would result in saving considerable ground space which is valuable, and not only would a more vigorous and uniform setting of lettuce be obtained, but the treatment would also eliminate many weak and undesirable plants, which are more likely to be susceptible to disease. In other words, much of the selection would be done more cheaply and easily by sifting the seed than as it is done at the present time, by selection in the seed bed. A sieve of the size mentioned can easily be made by purchasing from almost any tin shop a piece of colander tin of 1 millimeter mesh, which can very readily be soldered to a suitable rim, or even fastened to a tomato can which has had the bottom removed.

Our experiments in sifting seed have been confined, however, for the most part to lettuce seed; and, while these seeds can be separated in this way very easily, much more difficulty would be experienced in separating some other types of seed, such as turnip or tobacco; and another objection to this method is that the size and weight of seeds do not necessarily correspond, that is to say, a large seed may not necessarily be a heavy one. When seeds are separated by sifting, while the largest size contains practically all of the heaviest seeds and the lighter seed is practically all in the small sizes, there will be a few light seeds in the larger size and a few heavy seeds in the smaller sizes, so that this method by no means gives an absolute division of the seeds by weight, which is the ideal method of seed selection.

Mr. A. D. Shamel of the Connecticut (New Haven) Experiment Station uses a very satisfactory method for the separation of tobacco seed, which we can do no better than describe in his own words: —

This seed separator consists of a glass tube 1 inch in diameter and 5 feet long, and a glass receptacle for holding the seeds, having the diameter of the long glass tube, and so arranged with a finely woven wire screen in the bottom as to hold the seeds in the receptacle, and at the same time freely admit a current of air directly into the seed. The top of this receptacle is fitted with a coupling into which the long glass tube can be set and held in place. The current of air is developed by a common foot bellows and regulated with a valve. The seed to be separated is poured into the receptacle, usually about 1 to 2 ounces at a time, the glass tube set in place and a current of air pumped into the seed. The lightest seed and chaff are first blown out of the tube, and next the small seed. Small seed of the same character as the larger seed have proportionally more surface than the larger, consequently the small as well as the light seed is removed by this machine.

This seems to be the most satisfactory way of separating seed that has yet been devised, and no doubt some simple, inexpensive instrument modelled from this device will soon be available for every farmer and seed grower. The particular advantages of this method seem to be that this device is adaptable to all kinds of small seeds, the only adjustment needed being in the regulation of the amount or force of air sent through, and that by this method the seed is separated according to weight.

In conclusion, we believe it desirable with many kinds of garden seeds to separate the seed and discard all except the large, well-developed, mature and heavy seed, because: —

First. — About 33 per cent. of seeds as placed on the market consist of dirt, chaff, and small, undesirable seeds.

Second. — Small or light seeds do not germinate well, and their seeds produce only poor, small, undesirable plants, which prove inferior in every way.

Third. — Heavy seeds produce healthy, large, well-developed plants, that will give maximum crops.

Fourth. — Seed selection or separation is an inexpensive process that gives good results.

Asparagus Rust.

The past summer in most parts of Massachusetts has been an extremely dry one, and especially favorable, as was early anticipated, to an early and severe attack of asparagus rust. The confinement of the rust, or at least its injurious stage, to special localities has been the same this season as in other years; in other words, it has been confined to soils especially coarse, and easily affected by drought.

Since 1896 there have been about three severe outbreaks of the rust in this State, such outbreaks being identified with a dry summer, or at least with seasons where there have existed long periods between rainfalls. The fall or teleuto stage, however, has been present every year since

1896, and it has always been widely distributed. Any bed which has become once infected with this stage remains so, but fortunately the damage occurring from teleutospore infection is insignificant, and in the majority of cases not discernible. Asparagus rust has now become quite well distributed over the United States, but its virulence does not show itself in the same degree for every locality, and the problem of control is by no means everywhere the same, since factors enter into the problem which do not possess the same significance for all locations. In this State rust is most intimately associated with lack of vigor, and more particularly with those factors which underlie vigor, such as supply of water and judicious fertilizing. For this reason the most efficient remedies are based upon those practices the application of which induce vigor. There are a number of remedies which can be applied, some of which have given excellent results. Thorough cultivation and fertilization in more than one instance have given results which have proved superior to any other method of treatment. We have observed that the results from weekly cultivation combined with judicious fertilization have proved very satisfactory. Irrigation has also proved very effectual during dry seasons; but there is possibly a tendency for asparagus to become too succulent with repeated irrigation, which might possibly render the plant more susceptible to infection.

We also believe that an efficient practice pertaining to rust infection consists of burning the old brush in the fall, since a large number of teleutospores are destroyed, which, if left remaining in the ground over winter, would germinate freely in the spring and constitute a dangerous source of infection. We have repeatedly attempted to germinate teleutospores in the early winter, but failed. They will germinate freely in March, however. Moreover, the roots from infested plants, when transplanted in the greenhouse in the fall and left there for a year and allowed to develop tops, have never shown any tendency to rust. This would seem to indicate that not only is a resting period essential, as is usually the case for spores, but freezing also is essential. We are of the opinion that most beds are infected in this State by teleutospores during the spring and summer, and that the mycelium works up through the stem; and if the conditions for the plant are unfavorable, pustules bearing uredospores will break out in July or August, whereas, if the conditions for the plant are favorable, pustules bearing teleutospores will make their appearance during September or later.

In case uredospores break out in the plant during July and August, other beds in the vicinity, if in suitable condition, will invariably become infected. If, however, the crop is in a vigorous condition, even if located close by, it will resist the outbreak of the rust. This, indeed, has occurred many times in beds side by side, although of different age and vigor, and in the case of those beds more or less remote it may be stated that there are hundreds which have never had any uredo outbreak.

We observed a young bed of asparagus the past summer, about two years old, which had never been cut, and which had a teleutospore outbreak early in July. This bed suffered much from drought, and was not in an especially vigorous condition. It was, however, located on soil of fine texture, intermingled with coarse pebbles. There was little inclination for the plants of this bed to grow worse, notwithstanding the fact that drought prevailed, and it remained in practically the same condition all summer. On dry soil this never occurs, since it is the uredo stage that makes its appearance in these soils in July and August; and plants infected with this stage turn brown in a short time after they become infected. Moreover, the teleutospore outbreak occurring in summer is a perfectly harmless factor, as far as immediate infecting of the bed is concerned. Our studies of the rust problem have shown that there is an intimate connection existing between the texture and water contents of soils and uredospore outbreaks, and a series of water determinations of different soils during the season would probably bring out some interesting facts.

Spraying with Bordeaux mixture has not proved satisfactory in this State as a means of controlling the rust, and little or no use is now made of it for this purpose.

Some reports have been made concerning the use of the sulphur wash spray recommended by Prof. R. E. Smith, formerly of this station. This mixture, which consists of sulphur, soap, potash and water, possesses remarkable sticking qualities, and it is undoubtedly the most efficient mixture recommended for spraying for asparagus rust.

AN APPLICATION OF THE COPPER SULFATE TREATMENT.

Early in the summer the college pond became so overrun with Algæ as to be unsightly, and the smell of this decaying vegetable matter was so unpleasant that it became necessary to treat it.

Microscopic examinations of the water showed that it contained a considerable amount of short suspended filaments, of a slightly whitish or greenish color, which proved to be *Anabæna flos-aquæ*, a form of Algæ found frequently in public water supplies, and which gives rise to considerable trouble. The water content of the pond was roughly determined, and then treated with 1 part of copper sulfate to 4,000,000 parts of water. The required amount of copper sulfate was placed in a loosely woven sack and hung over the stern of a canoe, which was paddled around the pond in concentric circles for about one-half an hour, when all the copper sulfate was dissolved. This is the method recommended by Drs. Moore and Kellerman in their work on treating reservoirs with copper sulfate. A careful examination of samples taken twenty-four hours after treatment showed a slight decrease in *Anabæna*, and in two or three days it had practically disappeared.

Spirogyra, which was present along the shores near the inlet at the time of treatment, was not affected, and subsequently a number of large clumps were found in a flourishing condition in different parts of the pond, and many forms of Algæ, such as *Desmids* and *Diatams*, appeared not to be in the least affected by the treatment. Neither did the animal life seem to be affected in any way by the treatment, as no ill effects could be noted on the fish, frogs, tadpoles or other fauna inhabiting the water.

Of the *Protozoa*, the *Ceratium* was very numerous both before and after treatment, and was in no wise affected by the copper. *Daphna*, a form of Crustacea, was also plentiful, and experienced no ill effects from the copper treatment.

From day to day the bacterial contents of the water were determined, with the results shown in the following table :—

Copper Sulfate Test on Massachusetts Agricultural College Pond Water.

Date of taking Sample.	Number of Bacteria per Cubic Centimeter of Water.
1905.	
June 17 (one hour after treatment),	6,224
June 19,	3,463
June 20,	219
June 21,	336
June 22,	1,583
June 23,	1,187
June 24,	538
June 25,	1,144
June 26,	1,399
June 27,	1,144
June 28,	616
June 29,	763
June 30,	1,145
July 1,	1,078
July 3,	1,078
Sept. 16,	990
Sept. 17,	1,017
Sept. 18,	990
Sept. 19,	636

From this table it will be seen that the bacteria decreased very rapidly for the first few days after treatment, and, while they slowly increased again, they never reached their former numbers. The results obtained on June 24, 28 and 29 may be attributed to an unusually clear or settled state of the water on those days, while when the other samples were taken the water was considerably agitated, either from the effects of rain or wind.

A second treatment was contemplated in September for the purpose of studying the effects of copper sulfate on bacteria; but as the bacteria showed no appreciable increase at this time, we thought it not worth while to inaugurate another experiment. Samples of water taken one hour and twenty-four hours after treatment were tested for copper by the foods and feeding department of the station; and, while possible traces of the copper were found, they were so small and uncertain that no copper could be reported. In these tests the ferrocyanide method was employed, which in numerous other cases has failed to give reliable results where such small quantities of copper are present.

At the time these chemical tests were being made for copper there came to our notice a test described and recommended by Dr. Ewerts,[1] which claimed to detect one part of copper in 30,000,000 parts of water. This test is based on the inhibiting action of copper to diastatic action. This method was given a trial in the foods and feeding chemical laboratory, and found to be unsatisfactory. Quite likely, however, a detailed study of this latter method, together with some practice, will prove it to be of some value.

The result of this single experiment with copper sulfate in treating the college reservoir is not sufficient in itself to allow deductions of great value. They corroborate, however, the experiments made by Messrs. Moore and Kellerman on the Belchertown reservoir, and those made elsewhere, in showing that *Anabæna* is extremely susceptible to copper, and can readily be killed by this method of treatment. Moreover, the general clearing up and rapid disappearance of odor from the water two or three days after treatment, together with the falling off of bacteria, was quite noticeable. It should be stated, however, that there was a fall of about 20° in the temperature on the third day after treatment, which would have a tendency to affect *Anabæna;* and about one and one-half inches of rain fell between the 19th and 24th of June.

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[1] Ztschr. Pflanzenkrank, Bd. XIV., 3 Heft., p. 133.

A Comparison of the Numbers of Bacteria in Sterilized and Unsterilized Soils.

BY A. VINCENT OSMUN.

There has been repeated inquiry as to the effect sterilization of soil has upon its bacterial flora. In the absence of any reliable experiments touching upon this question, it has frequently been assumed that by soil sterilization the bacteria, and especially the beneficial ones, are destroyed, hence injuring the soil. In regard to this question, it may be stated that little is known about either the so-called beneficial or injurious bacteria of greenhouse soils; and, in consequence of a paucity of knowledge upon this phase of the subject, positive statements are out of place. From what is already known about the effects of soil sterilization upon plant growth and the changes which such soil undergoes, it might be assumed upon *a priori* grounds that soil bacteria would be found to exist more abundantly in sterilized soil than in unsterilized soil. Moreover, it must be borne in mind that absolute sterilization is never accomplished, but something more closely approaching pasteurization takes place. All bacteria are by no means killed, as has been shown by various tests made at this station.[1] Subjecting soils to steam heat has a marked stimulating effect on the growth of plants. Observations at this station and experience of growers have shown this to be true. Just why this treatment of soil should stimulate the growth of plants is not known. Sorauer[2] suggests that steam heat makes the humus compounds more available to plants. It is not unlikely that steam flowing through a soil also improves its mechanical condition.

The stimulating effect of soil sterilization on plant growth suggested a similar effect on the bacterical content of soil so treated; and in order to obtain more evidence regarding this point this experiment was planned: —

Two boxes about 20 inches square and 9 inches deep and of equal weights were filled to the depth of about 5 inches with equal amounts by weight of soil from the supply bin of the station greenhouse. Before filling the boxes a quantity of soil from the bin was thoroughly mixed, and the boxes filled from that, so that the soils in the two boxes were as nearly alike as possible. The soil in one box was treated for half an hour with flowing steam applied through perforated tubes buried beneath the surface; the soil in the other box was untreated. One week after sterilization a sample was taken from each box for the determination of the numbers of bacteria in the soil, after which the boxes were placed on a platform scale and brought to equal weights with water. Water was similarly applied every day during the experiment, and the soil always contained from 17 to 20 per cent. moisture. Samples for the determination of the quantitative bacterial content of these soils were taken at intervals of about two weeks. The soil was frequently stirred, and at the times of sampling the entire contents of each box were thoroughly mixed and pulverized.

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[1] Hatch Experiment Station, Massachusetts Report, 1902, pp. 77, 78.

[2] Sorauer, The Physiology of Plants, pp. 45, 46.

The results of this experiment are tabulated in the accompanying table: —

Showing the Relative Number of Bacteria in Sterilized and Unsterilized Loam.

Date of taking Sample.	Number of Bacteria per Gram of Dry Soil.	
	Sterilized.	Unsterilized.
1905.		
April 3,	6,742,000	56,273,000
April 18,	64,596,000	39,080,000
May 1,	66,089,000	31,372,000
May 16,	29,963,000	8,029,000
June 1,	26,666,000	14,634,000

The figures in this table show that steam flowing through soil for half an hour not only does not kill all the bacteria in that soil, but that it seems to act as a stimulus, causing rapid mutiplication of numbers. Practically all vegetative forms would be killed, but most spores would be uninjured, and, given favorable conditions after treating, would germinate. One week after sterilization the treated soil contained nearly 7,000,000 bacteria per gram. This number is probably considerably in excess of the number in the same soil immediately after sterilization, but it indicates that treating soil with live steam at about 210° F. for half an hour does not kill all the bacteria in that soil. The untreated soil contained a good number of bacteria at the beginning, — about 56,000,000.

During the four weeks immediately after the first samples were taken there was a phenomenal increase in the number of bacteria in the sterilized soil. From 7,000,000 per gram at the beginning the number had advanced to nearly 65,000,000 at the end of two weeks, and after four weeks to over 66,000,000. On the other hand, the number in the untreated soil showed a steady decrease, for which no cause is at present apparent.

After six weeks the numbers of bacteria in both sterilized and unsterilized soils had dropped way below the numbers found at the end of four weeks. During the next two weeks the sterilized soil continued to drop off, though not to any great extent, while the unsterilized soil advanced.

At this point it became necessary to discontinue the taking of samples because of the press of other work.

We are unable to account for the decrease in numbers of bacteria in either sterilized or unsterilized soil. A similar decrease in numbers of bacteria has been noted in other experiments in the greenhouse in which unsterilized soil was used. The temporary increase in numbers in the sterilized soil may be attributed to the stimulus given by the steam heat; and it appears also that sterilization had a tendency to overcome, for a time at least, the antagonistic agency or agencies which caused the decrease in the unsterilized soil.

More extended experiments and observations are necessary before definite conclusions can be reached regarding the effect of so-called sterilization on the bacterial contents of soils; but from the results obtained in this experiment and from tests of other soils, both sterilized and unsterilized, we may conclude that steam treatment of soils greatly stimulates bacterial development in them, and that if certain as yet unknown adverse conditions can be removed, the high numbers may be retained indefinitely.

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD, H. T. FERNALD.

The year 1905 has been marked by a great abundance of insects of many kinds, while the two years preceding were equally marked by their scarcity. To this fact is probably due the large increase in the amount of correspondence the present year, nearly two thousand letters having been sent out, besides an unrecorded amount of printed matter, in answer to questions received.

Investigations as to the number of broods and times of appearance of the codling moth and oyster-shell scale have been continued during the season, and should be repeated for several years to come, that reliable date averages may be obtained, and thus the best times for the treatment of these insects be ascertained.

Several private insecticides have been more or less tested and the results noted, statements of these having been supplied in each case to the persons sending the materials. While some of these substances were shown to have a certain value for the destruction of insects, it was noticeable that they were no more effective than well-known insecticides costing less, or that they were injurious to the foliage of the plants they were tested on. In fact, none of the materials tested at this station during the year can be considered as adding anything of value to our present list of standard insecticides, though it has taken considerable time from other work to establish these negative results.

The collections of the division have, as usual, been given the needed care and have been added quite considerably to during the year, while additional facts as to the distribution of insect pests in Massachusetts and their habits have been gathered and recorded. The card catalogue has been kept abreast of the new publications and improved in many ways, and requests for the information it contains are frequently received from other stations and from individuals.

Some study has been given to the carnation twitter, and the identity of the insect causing this trouble has been ascertained with considerable though not absolute certainty. Further investigations on this subject will be made during the coming year if material to study can be obtained.

Special researches have also been continued on the Asilidæ or robber flies; the Pyralidæ, a group including many very injurious insects; the Bombinæ or bumble bees and their habits; and on the Sphecidæ or digger wasps, these studies being of the entire groups; while a Cecidomyiid on oak, the stalk borer and several other species have received special attention individually.

The erection of a new greenhouse during the summer has greatly improved the facilities of the division for entomological research, besides being an excellent example of modern greenhouse construction. With a house which is reasonably tight and which can be kept warm during the winter it has been possible to begin a series of experiments to determine the resistant power of various forcing crops to fumigation. The business of raising crops under glass in Massachusetts is a very large one, and in too many places is greatly interfered with by the presence of insects which can only be controlled by fumigation with hydrocyanic acid gas. The strength of fumigation necessary to destroy these insects is now well known in most cases, but the charge which the plants can resist under all conditions of growth is not; and many an owner has refused to fumigate a badly infested house for fear of killing his plants along with the insects. From the experiments now under way, and which it will require several years to complete, it is believed that data can be obtained of such a nature that any person who desires to treat a greenhouse will be able to do so with entire safety to the plants, and yet kill the insects which may be present.

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INSECTS OF THE YEAR.

The present year has been favorable for the rapid increase of insects in Massachusetts, and, though no one species has been present in overwhelming abundance, each has done its part in attacking crops of all kinds.

The San José scale is as abundant as it has ever been in the State, and is spreading farther each year. Where its presence is neglected it makes itself speedily felt; but with the methods we now have for its control there is no reason why it should be more than a nuisance in the future, requiring treatment every two or three years, like any of our other pests.

Cutworms and wire worms have given much trouble, particularly in the eastern and central portions of the State, while but little has been heard of root maggots this season.

The army worm has caused considerable injury locally on some of the cranberry bogs and elsewhere in southeastern Massachusetts, and in the central and western parts of the State the moths of this pest have been more abundant than for some time. It has now been nearly ten years since the last outbreak of this insect, and it is not unlikely that another may be due before long, if unknown factors do not develop to prevent it.

Inquiries about insects have covered a wider range than usual, but the most numerous questions have been about several species of scale insects, plant lice of different kinds, red spiders, borers, datanas, the bean weevil and the red-humped apple-tree caterpillar.

Since the Legislature placed the work on the gypsy and brown-tail moths in the hands of a special commission, no particular attention has been given them here; but some facts observed in connection with their distribution are here noted, as they have been gathered by members of the station. A few tents of the brown-tail moth were observed in Amherst last spring and others were received from Martha's Vineyard, while several were found on Nantucket last fall, showing that this insect is widely distributed over the State. Several cases have also been reported to the station of the presence of the gypsy moth outside of the territory originally occupied by it, and these observations have been confirmed by inspectors of the Gypsy Moth Commission. That this insect is now rapidly spreading there can be no doubt, and it is too probable that the entire State will before long be infested by these two insects, which are among the worst enemies to man which occur in the United States.

APPENDIX.

COMPILATION OF ANALYSES OF AGRICULTURAL CHEMICALS, REFUSE SALTS, ASHES, LIME COMPOUNDS, REFUSE SUBSTANCES, GUANOS, PHOSPHATES AND ANIMAL EXCREMENTS.

H. D. HASKINS.

1. Chemicals, refuse salts, etc.
2. Ashes, marls, lime compounds, etc.
3. Refuse substances.
4. Guanos, phosphates, etc.
5. Animal excrement, etc.
6. Average per cents. of the different ingredients found in the preceding compilation of analyses, calculated to pounds per ton of 2,000 pounds.

1868 to 1905.

This compilation does not include the analyses made of licensed fertilizers. They are to be found in the different bulletins and annual reports of the State inspector of fertilizers from 1873 to 1895, which are contained in the reports of the secretary of the Massachusetts State Board of Agriculture for these years, and in the bulletins of the division of chemistry of the Hatch Experiment Station of the Massachusetts Agricultural College since March, 1895.

No valuation is stated in this compilation, as the basis of valuation changes from year to year.

In the following compilation of analyses of agricultural chemicals, refuse materials, manurial substances, etc., the signification of the star (*) prefixed to the name of the substance is that the compilation is made up of analyses subsequent to the year 1897. It was believed that a compilation made up of more recent analyses would more nearly represent the present general chemical character of the substances, and would therefore be of more practical value.

It must be understood that the chemical character of many of the refuse substances used for manurial purposes is constantly undergoing changes, due to frequent variations in the parent industry.

As a rule, in all succeeding analyses the essential constituents are determined and stated; blanks do not imply the absence of the non-essentials.

1. *Chemicals, Refuse Salts, etc.*

FERTILIZER MATERIALS.	Analyses.	Moisture.	Ash.	NITROGEN.			POTASH.			TOTAL PHOSPHORIC ACID.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
*Carbonate of potash, high grade,	6	3.38	–	–	–	–	67.20	55.68	60.92	–	–	–	–	–	–	–	–	–	–	–	–	–	–
*Carbonate of potash and magnesia,	2	18.22	–	–	–	–	20.00	18.48	19.24	–	–	–	–	–	–	–	–	19.52	–	–	–	–	.39
Carnalite,	1	–	–	–	–	–	–	–	13.68	–	–	–	–	–	–	7.66	–	13.19	–	.56	–	41.56	–
*Kainit,	9	2.18	–	–	–	–	13.65	10.90	12.47	–	–	–	–	–	–	18.97	2.37	6.37	–	20.25	–	20.64	2.13
Krugite,	1	4.82	–		–	–	–	–	8.42	–	–	–	–	–	–	5.27	12.45	8.79	–	31.94	–	6.63	14.96
*Muriate of potash,	70	1.56	–	–	–	–	54.80	45.40	49.89	–	–	–	–	–	–	6.69	–	.55	–	–	–	48.80	.70
*Nitrate of potash,	5	.98	–	14.58	11.60	13.30	45.62	43.88	44.57	–	–	–	–	–	–	–	–	–	–	–	–	–	–
*Nitrate of soda,	93	1.52	–	16.57	14.14	15.47	–	–	–	–	–	–	–	–	–	35.50	–	–	–	–	–	.50	.50
*Nitre lime,	2	.92	–	–	–	8.42	–	–	–	–	–	–	–	–	–	–	29.30	–	–	–	–	–	2.28
Nitre salt cake,	2	6.03	–	–	–	2.29	–	–	.87	–	–	–	–	–	–	29.56	–	–	–	47.77	–	–	3.92
Phosphate of potash,	1	3.76	–	–	–	–	–	–	32.55	–	–	37.50	–	37.50	–	–	–	–	–	13.43	–	–	.92
Phosphate of ammonia,	1	6.05	–	–	–	10.37	–	–	–	–	–	43.86	–	–	–	–	–	–	–	12.46	–	–	.82
*Refuse from manufacture of cyanide of potash,	1	39.23	–	–	–	.96	–	–	7.36	–	–	–	–	–	–	–	–	–	–	–	–	–	–
*Sulfate of ammonia,	23	.99	–	22.16	19.44	20.74	–	–	–	–	–	–	–	–	–	–	–	–	–	60.00	–	–	–
*Sulfate of potash, high grade,	48	.82	–	–	–	–	53.15	45.70	49.25	–	–	–	–	–	–	4.46	–	1.50	–	45.72	–	–	.75
*Sulfate of potash-magnesia,	24	3.83	–	–	–	–	31.68	19.55	25.34	–	–	–	–	–	–	6.25	2.57	13.86	–	44.72	–	1.95	2.26

1. *Chemicals, Refuse Salts, etc.* — Concluded.

FERTILIZER MATERIALS.	Analyses.	Moisture.	Ash.	NITROGEN.			POTASH.			TOTAL PHOSPHORIC ACID.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
* Silicate of potash,	4	7.86	-	-	-	-	27.62	21.48	20.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Sulfate of magnesia,	10	23.76	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.82	17.40	-	36.10	-	-	5.73
* Sulfate of soda,	1	1.38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	59.43	-	-	-
Saltpetre waste,	12	2.54	-	3.30	.52	2.22	30.94	1.55	13.66	-	-	-	-	-	-	37.04	.75	.19	-	1.85	-	46.25	-
* Vegetable potash,	6	3.63	-	-	-	-	27.84	23.96	25.95	-	-	2.55	-	-	-	-	20.65	-	-	-	-	-	9.70
2. *Ashes, Marls, Lime Compounds, etc.*																							
* Acetylene gas-tank refuse,	1	4.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	59.15	-	-	-	-	-	-
Ashes of spent tan bark,	5	4.84	-	-	-	-	2.87	.60	1.81	2.77	.13	1.36	-	-	-	-	31.11	3.39	1.78	-	-	-	25.21
Ashes from cremation of swill,	15	4.86	-	-	-	-	8.83	1.25	3.97	32.36	7.47	14.16	-	-	-	-	33.58	1.87	4.65	-	-	-	21.57
Ashes from blue works,	1	12.14	63.78	-	-	-	-	-	9.02	-	-	-	-	-	-	-	-	-	-	-	-	-	12.30
* Ashes from cremation of garbage,	3	3.01	-	-	-	-	6.01	3.72	5.13	10.21	7.16	8.77	-	-	-	15.65	20.22	1.16	9.22	4.57	10.85	4.75	28.42
* Ashes from hay and straw,	1	.40	-	-	-	-	-	-	1.55	-	-	1.02	-	-	-	-	5.22	-	-	-	-	-	66.35
* Ashes from jute waste,	1	.19	-	-	-	-	-	-	.51	-	-	.54	-	-	-	3.84	6.04	.39	7.60	-	-	.57	81.02
* Ashes from peach tree trimmings,	1	.54	-	-	-	-	-	-	4.92	-	-	2.44	-	-	-	7.53	18.74	-	10.50	2.20	-	-	13.54
* Ashes from soft coal and sawdust,	1	3.36	-	-	-	-	-	-	.73	-	-	.74	-	-	-	-	2.80	-	-	-	-	-	69.53

Ammoniated marl, ...	1	3.31	–	–	–	1.61	–	–	–	–	–	10.39	–	.41	9.98	–	–	–	–	–	–	–	–
* Bleachery refuse, ...	2	4.19	–	–	–	–	1.24	.35	.79	–	–	–	–	–	–	11.69	35.79	–	–	–	–	–	23.09
Bituminous coal ashes, ...	2	3.66	–	–	–	–	–	–	.38	–	–	.44	–	–	–	–	1.88	–	–	–	–	–	74.17
* Brick-yard ashes, ...	2	.58	–	–	–	–	3.59	3.32	3.45	1.61	1.33	1.47	–	–	–	–	24.33	–	–	–	–	–	47.63
* Coal and wood ashes, ...	1	1.32	–	–	–	–	–	–	.44	–	–	1.15	–	–	–	–	2.39	–	–	–	–	–	80.94
* Cotton-seed hull ashes, ...	33	7.31	–	–	–	–	32.80	14.08	22.53	15.53	6.26	8.49	–	6.88	1.28	–	7.03	12.64	–	7.31	–	–	17.12
* Corn-cob ashes, ...	2	5.47	–	–	–	1.18	42.38	7.08	24.73	7.08	2.37	4.72	–	–	–	–	7.00	–	–	–	–	–	38.12
* Carbonate of lime, ...	2	.45	–	–	–	–	–	–	–	–	–	–	–	–	–	–	52.31	–	–	–	–	–	–
Gypse, ...	1	1.64	–	–	–	–	–	–	–	–	–	–	–	–	–	–	50.87	–	–	–	–	–	2.87
* Gas-house lime, ...	5	11.16	–	–	–	–	–	–	–	–	–	–	–	–	–	–	48.19	8.30	–	19.66	–	–	8.99
Green sand marl (Virginia), . . .	1	1.25	–	–	–	–	–	–	1.14	–	–	9.37	–	–	–	–	25.78	–	5.13	–	–	–	41.32
* Hemp ashes, ...	1	–[1]	–	–	–	–	–	–	2.48	–	–	1.74	–	–	–	–	60.47	–	–	–	–	–	3.14
Hard-pine wood ashes, ...	1	.75	–	–	–	–	–	–	10.16	–	–	2.24	–	–	–	–	24.95	–	–	–	–	–	29.90
* Lime refuse from soda factory, . .	1	24.07	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14.86	–	1.36	23.14	–	–	1.63
Lime waste from sugar factory, . .	1	36.30	–	–	–	–	–	–	.22	–	–	2.25	–	–	–	–	27.51	–	–	–	–	–	.32
Lime, ...	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	93.63	–	–	–	–	–	1.33
* Lime-kiln ashes, ...	10	11.35	–	–	–	–	4.73	.43	2.04	1.58	.03	.78	–	–	–	–	41.49	1.30	–	–	–	–	6.78
* Leather-scrap ashes, ...	3	5.94	–	–	–	.15	3.36	1.00	2.23	3.96	1.80	2.89	–	–	–	–	7.80	–	–	–	–	–	46.08
Logwood ashes, ...	1	1.50	–	–	–	–	–	–	.08	–	–	2.30	–	–	–	–	3.90	–	–	–	–	–	9.70
Mill ashes, ...	1	.53	–	–	–	–	–	–	1.60	–	–	.46	–	–	–	–	34.93	1.35	–	–	–	–	36.36
Magnolia ashes (Florida), ...	1	1.58	–	–	–	–	–	–	2.56	–	–	.45	–	–	–	–	–	–	–	–	–	–	6.12
Massachusetts marls, ...	7	13.70	–	–	–	–	–	–	.24	2.72	.06	1.05	–	–	–	–	40.50	.64	.69	–	28.57	–	3.44

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[1] None.

2. *Ashes, Marls, Lime Compounds, etc.* — Concluded.

FERTILIZER MATERIALS.	Analyses.	Moisture.	Ash.	NITROGEN.			POTASH.			TOTAL PHOSPHORIC ACID.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
* Marl,	1	15.54	–	–	–	.01	–	–	.29	–	–	.02	–	–	–	–	– [1]	–	–	–	–	–	–
Marl (North Carolina),	1	.70	–	–	–	–	–	–	.04	–	–	.56	–	–	–	–	21.95	.61	–	–	–	–	50.18
* Nova Scotia plaster (gypsum),	17	6.45	–	–	–	–	–	–	–	–	–	–	–	–	–	–	33.74	.75	–	44.87	–	–	5.79
Olive earth (Virginia),	1	1.97	–	–	–	–	–	–	.24	–	–	13.73	–	–	–	–	19.16	–	6.00	–	–	–	50.55
Onondaga plaster (New York gypsum),	4	13.27	–	–	–	–	–	–	–	–	–	–	–	–	–	–	30.00	4.66	–	32.50	8.20	–	9.83
* Oyster-shell lime,	2	– [2]	–	–	–	–	–	–	–	–	–	.38	–	–	–	–	55.54	–	–	–	9.45	–	8.82
* Picker-waste ashes,	1	.28	–	–	–	–	–	–	6.56	–	–	1.18	–	–	–	–	–	–	–	–	–	–	63.43
* Patent-process lime,	1	– [2]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	57.87	–	–	–	–	–	9.03
* Prepared lime,	1	– [2]	–	–	–	–	–	–	–	–	–	–	–	–	–	3.99	69.48	.50	1.50	–	–	–	–
* Pine-wood ashes,	1	2.76	–	–	–	–	–	–	4.37	–	–	3.07	–	–	–	–	23.61	–	–	–	–	–	37.46
* Peat,	5	45.30	20.47	1.88	.34	.92	–	–	.04	.11	– [1]	.08	–	–	–	–	.88	–	–	–	–	–	16.23
* Plastering,	1	7.20	–	–	–	–	–	–	–	–	–	.22	–	–	–	–	11.50	–	–	–	–	–	66.50
Peat ashes,	1	4.67	–	–	–	–	–	–	.46	–	–	.11	–	–	–	–	2.28	1.63	6.13	–	–	–	45.17
* Pulp ashes,	1	– [2]	–	–	–	–	–	–	.46	–	–	.12	–	–	–	–	67.72	–	–	–	–	–	7.00
Railroad-tie ashes,	1	4.70	–	–	–	–	–	–	.92	–	–	.56	–	–	–	–	2.51	–	–	–	–	–	80.20
* Refuse ashes from sawdust,	1	13.92	–	–	–	–	–	–	3.58	–	–	7.92	–	–	–	–	34.76	–	–	–	–	–	25.27

Sea-weed ashes,	1	1.47	–	–	–	–	–	–	.92	–	–	.30	–	–	–	8.76	6.06	4.37	–	2.98	–	6.60	68.65
*Tan-bark ashes,	1	1.50	–	–	–	–	–	–	.52	–	–	.77	–	–	–	–	24.29	–	–	–	–	–	13.54
*Wood ashes,	5.55	12.08	–	–	–	–	13.58	1.12	5.42	6.07	.06	1.42	–	–	–	–	32.98	3.31	7.43	–	–	–	16.51
*Wool-waste ashes,	1	8.40	–	–	–	–	–	–	27.24	–	–	.26	–	–	–	–	2.88	–	–	–	–	–	27.82
*Wood charcoal,	2	3.65	–	–	–	–	–	–	.40	–	–	.16	–	–	–	–	–	–	–	–	–	–	1.58
*Walnut-wood ashes,	1	3.79	–	–	–	–	–	–	5.06	–	–	2.07	–	–	–	–	40.73	–	–	–	–	–	2.29
*Waste lime from tannery,	2	.88	–	–	–	.65	–	–	–	–	–	–	–	–	–	–	54.78	–	–	–	–	–	2.83
*Waste lime,	1	.80	–	–	–	–	–	–	–	–	–	–	–	–	–	–	74.12	–	–	–	–	–	.38
Virginia marls,	2	15.98	–	–	–	–	.61	.37	.49	.09	.08	.09	–	–	–	–	7.25	.21	–	.66	7.25	–	64.23

3. *Refuse Substances.*

Ammoniate,	1	5.88	–	–	–	11.33	–	–	–	–	–	3.43	–	–	–	–	–	–	–	–	–	–	1.38
*Blood and bone,	5	5.97	–	7.19	5.70	6.23	–	–	–	12.86	11.38	12.14	–	4.41	7.73	–	–	–	–	–	–	–	–
*Bone dust,	1	5.06	–	–	–	3.06	–	–	–	–	–	17.80	–	7.24	10.56	–	–	–	–	–	–	–	–
Bone soup,	1	82.92	7.07	–	–	1.14	–	–	–	–	–	1.26	–	–	–	–	–	–	–	–	–	–	–
*Bone from fish,	1	8.78	–	–	–	4.82	–	–	–	–	–	23.54	–	8.04	15.50	–	–	–	–	–	–	–	–
*Broom-corn seed,	1	7.40	–	–	–	1.51	–	–	.50	–	–	.57	–	–	–	–	–	–	–	–	–	–	–
*Banana skins,	1	13.99	–	–	–	.24	–	–	5.46	–	–	1.80	–	–	–	–	–	–	–	–	–	–	–
Blue-green algæ (*Lyngbia Majasculas*),	1	16.26	–	–	–	4.25	–	–	.79	–	–	.19	–	–	–	3.53	2.06	1.18	–	–	–	–	5.53
*Burned bone,	5	2.06	–	–	–	–	–	–	–	–	–	37.33	–	2.71	35.66	–	52.12	–	–	–	–	–	.96
*Cocoanut-fibre pith,	1	6.20	3.78	–	–	.34	–	–	.84	–	–	.03	–	–	–	–	.57	–	–	–	–	–	1.01

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[1] Trace.

[2] None.

3. *Refuse Substances* — Continued.

FERTILIZER MATERIALS.	Analyses.	Moisture.	Ash.	NITROGEN.			POTASH.			TOTAL PHOSPHORIC ACID.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
*Cocoa shells,	1	3.88	–	–	–	2.33	–	–	2.48	–	–	.36	–	–	–	–	.76	–	–	–	–	–	–
*Concentrated wool washings,	1	41.13	–	–	–	1.09	–	–	10.15	–	–	.10	–	–	–	–	–	–	–	–	–	–	–
*Condensed bone steam,	1	81.75	–	–	–	1.94	–	–	–	–	–	.07	–	–	–	–	–	–	–	–	–	–	–
*Castor-bean pomace,	6	7.64	5.70	5.85	4.68	5.18	3.40	.64	1.20	2.26	1.57	2.12	–	–	–	–	.87	.29	–	–	–	–	1.75
*Cassava waste,	1	9.03	–	–	–	.33	–	–	.28	–	–	.06	–	–	–	–	.61	–	–	–	–	–	–
*Cotton-seed meal,	1.27	6.85	–	–	7.99	3.24	6.74	1.92	1.41	1.64	3.30	1.71	2.56	–	–	–	–	–	–	–	–	–	.28
*Cotton-seed dust,	1	4.38	–	–	–	1.22	–	–	1.48	–	–	.54	–	–	–	–	1.48	–	–	–	–	–	–
*Cotton-seed droppings,	1	4.08	–	–	–	.96	–	–	1.85	–	–	.20	–	–	–	–	.66	–	–	–	–	–	–
*Cotton compost,	1	42.51	–	–	–	–	.93	–	–	.56	–	–	.39	–	–	–	–	–	–	–	–	–	–
*Cotton waste, wet,	4	24.02	34.42	1.34	.84	1.21	.76	.43	.64	.74	.56	.65	–	–	–	–	2.73	–	–	–	–	–	38.16
*Cork dust,	1	.74	–	–	–	.59	–	–	.33	–	–	.10	–	–	–	–	.74	.08	–	–	–	–	.24
*Coral formation,	1	39.26	–	–	–	.28	–	–	.14	–	–	.21	–	–	–	–	23.14	1.39	–	–	–	–	16.98
*Cotton waste, dry,	9	6.45	13.57	1.60	.55	1.03	1.62	.48	1.13	.66	.08	.32	–	–	–	–	1.73	–	–	–	–	–	14.61
Cotton dust,	2	32.68	50.93	–	–	.78	–	–	.45	–	–	.32	–	–	–	–	–	–	–	–	–	–	42.22
*Dried blood,	34	10.45	6.37	13.55	7.99	10.16	–	–	–	8.70	.03	2.50	–	–	–	–	–	–	–	–	–	–	–
Dried soup from meat and bone,	1	14.80	8.40	–	–	9.97	–	–	–	–	–	.53	–	–	–	–	–	–	–	–	–	–	.64

Dried soup from rendering cattle feet,	1	10.80	7.50	-	-	14.47	-	-	-	-	-	.46	-	-	-	-	-	-	-	-	-	-	.26
* Dry ground fish, ...	59	8.87	-	10.48	6.06	8.36	-	-	-	16.07	5.50	8.87	-	4.64	4.18	-	-	-	-	-	-	-	-
* Damaged grain, ...	3	42.15	-	1.97	.84	1.44	.43	.16	.28	.83	.35	.55	-	-	-	-	-	-	-	-	-	-	-
* Deposit from Charles River, . .	1	21.46	-	-	-	.95	-	-	.59	-	-	.74	-	-	-	-	1.81	-	-	-	-	-	44.27
* Dredgings from Cape Cod, . . .	1	18.99	-	-	-	.99	-	-	.13	-	-	.07	-	-	-	-	-	-	2.06	-	-	.54	-
* Deposit from pond, ...	1	4.01	-	-	-	.41	-	-	.26	-	-	.32	-	-	-	-	1.62	-	-	-	-	-	-
Eel grass, ...	2	35.39	15.60	.96	.70	.83	1.61	.21	.91	.41	.22	.32	-	-	-	1.63	2.13	.11	-	-	-	-	1.06
* Factory waste, ...	5	13.11	32.20	2.95	.47	1.55	11.78	.18	3.57	1.07	.29	.60	-	.24	-	-	13.02	-	-	6.73	-	-	6.14
Felt refuse, ...	1	29.24	33.53	-	-	5.26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* Fibre waste, ...	1	61.53	-	-	-	.22	-	-	.49	-	-	.10	-	-	-	-	.36	-	-	-	-	-	.53
* Fleshings, ...	1	6.96	43.14	-	-	7.55	-	-	-	-	-	.31	-	-	-	-	-	-	-	-	-	-	-
* Fresh-cut bone, ...	1	24.98	-	-	-	3.00	-	-	-	-	-	16.85	-	5.26	11.59	-	-	-	-	-	-	-	-
Fish with 20 to 40 per cent. water, .	10	30.19	20.59	7.41	4.22	5.97	-	-	-	8.32	4.68	7.09	.74	2.69	3.64	-	-	-	-	-	-	-	1.68
Fish with more than 40 per cent. water,	10	45.46	15.50	7.60	2.43	4.97	-	-	-	8.56	2.94	5.08	1.17	1.33	2.58	-	-	-	-	-	-	-	1.35
Fresh-water mud, ...	1	40.37	-	-	-	1.37	-	-	.22	-	-	.26	-	-	-	-	1.27	.29	1.80	-	-	-	18.26
* Garbage tankage, ...	1	2.12	-	-	-	5.95	-	-	-	-	-	6.06	-	4.40	1.66	-	-	-	-	-	-	-	-
* German peat moss, ...	1	9.50	1.14	-	-	.72	-	-	.06	-	-	.05	-	-	-	-	.21	-	-	-	-	-	.36
* Ground tobacco stems, ...	8	8.84	20.20	2.72	.99	2.02	8.18	3.88	6.15	1.15	.32	.62	-	-	-	-	6.75	-	-	-	-	-	1.30
Ground bone, damaged by salt water,	1	32.81	-	-	-	1.78	-	-	-	-	-	17.21	-	5.26	11.95	-	-	-	-	-	-	-	-
* Ground bones, ...	2.53	5.03	66.14	5.94	.85	3.06	-	-	-	31.42	14.50	24.34	-	8.52	15.82	-	-	-	-	-	-	-	1.08
Glucose refuse, ...	1	8.10	-	-	-	2.62	-	-	.15	-	-	.29	-	-	-	-	.18	.02	-	-	-	-	.07
Horn shavings, ...	1	4.83	-	-	-	15.31	-	-	-	-	-	.42	-	-	-	-	-	-	-	-	-	-	-

3. *Refuse Substances* — Continued.

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
*Hoof meal,	1	4.10	–	–	–	15.19	–	–	–	–	–	.77	–	–	–	–	–	–	–	–	–	–	–
*Horn dust,	3	8.63	–	–	–	14.60	–	–	–	–	–	.04	–	–	–	–	–	–	–	–	–	–	–
Horn and hoof waste,	3	10.17	7.63	15.49	11.84	13.25	–	–	–	2.30	1.36	1.83	–	–	–	–	–	–	–	–	–	–	.24
*Hair waste,	1	6.52	22.77	–	–	9.22	–	–	.14	–	–	.51	–	–	–	4.10	–	–	–	–	–	–	–
*Hop refuse,	2	84.56	1.71	.69	.49	.59	.06	.05	.05	.11	.10	.10	–	–	–	–	–	–	–	–	–	–	.83
Ivory dust,	1	11.50	52.63	–	–	6.64	–	–	–	–	–	24.56	.97	17.97	5.62	–	–	–	–	–	–	–	–
*Jadoo fibre,	2	10.20	11.60	.97	.77	.87	.48	.38	.43	1.24	.26	.75	–	–	–	–	3.50	–	–	–	–	–	4.05
Jute waste,	1	13.10	–	–	–	1.50	–	–	.08	–	–	.72	–	–	–	–	–	–	–	–	–	–	–
*Kiln dust from brewery,	1	9.72	–	–	–	4.32	–	–	2.16	–	–	.96	–	–	–	–	.78	–	–	–	–	–	7.11
*Linseed meal,	7	8.65	–	6.42	5.26	5.78	1.58	1.46	1.52	1.59	1.36	1.47	–	–	–	–	–	–	–	–	–	–	.58
Lobster shells,	1	7.27	–	–	–	4.50	–	–	–	–	–	3.52	–	–	–	–	22.24	1.30	–	–	–	–	.27
*Meat meal,	1	3.22	8.55	–	–	9.23	–	–	–	–	–	3.08	–	–	–	–	–	–	–	–	–	–	–
Meat mass,	5	12.09	13.60	11.50	9.69	10.44	–	–	–	3.58	.56	2.07	–	–	–	–	–	–	–	–	–	–	.58
Meat scrap,	2	24.79	–	–	–	6.33	–	–	–	–	–	5.79	–	–	–	–	–	–	–	–	–	–	–
Morocco factory waste,	1	22.72	–	–	–	1.16	–	–	.36	–	–	2.56	–	–	–	–	19.60	–	–	1.24	–	–	24.17
*Meat and bone,	12	8.64	–	–	–	5.29	–	–	–	–	13.78	16.81	–	7.06	9.74	–	–	–	–	–	–	–	–

Mill sweepings,	1	9.49	–	–	–	3.76	–	–	.66	–	–	1.18	–	–	–	–	–	–	–	–	–	–	5.01
* Mill waste,	1	4.50	–	–	–	1.84	–	–	.58	–	–	1.07	–	–	–	–	–	–	–	–	–	–	–
Madder,	2	11.93	–	–	–	.91	–	–	2.40	–	–	.35	–	–	–	–	3.93	.51	–	–	–	–	4.67
* Milk cassein,	1	7.15	–	–	–	7.30	–	–	.76	–	–	8.06	–	–	–	–	11.78	–	1.40	–	–	–	.10
Mussel mud, wet,	1	60.01	27.29	–	–	.21	–	–	6.17	–	–	.10	–	–	–	.70	.93	.14	3.48	–	–	–	–
Mussel mud, dry,	1	2.24	72.02	–	–	.72	–	–	–	–	–	.35	–	–	–	–	23.39	–	8.26	–	–	–	37.60
* Muck and peat, wet,	28	67.58	9.97	1.35	.12	.46	.16	.02	.05	.19	.01	.06	–	–	–	–	.37	–	–	–	–	–	6.73
* Muck and peat, dry,	8	6.67	69.54	2.10	.26	.84	–	–	–	–	–	.31	–	–	–	–	.77	–	–	–	–	–	–
* Mud,	3	42.02	44.76	.65	.19	.35	–	–	.15	–	–	.02	–	–	–	–	.09	–	–	–	–	–	–
Oleomargarine refuse,	1	8.54	14.42	–	–	12.12	–	–	–	–	–	.88	–	–	–	–	–	–	–	–	–	–	.96
* Paper-mill dustings,	1	1.68	23.41	–	–	.35	–	–	.60	–	–	.13	–	–	–	–	.30	–	4.40	–	–	–	14.23
* Product from garbage plant,	1	4.14	–	–	–	2.56	–	–	.50	–	–	6.92	–	–	–	–	–	–	–	–	–	–	16.48
Pine barren grass,	1	8.48	2.40	–	–	.16	–	–	.07	–	–	.18	–	–	–	–	–	–	–	–	–	–	1.67
Pine needles,	1	9.48	3.42	–	–	.46	–	–	.03	–	–	.12	–	–	–	–	–	–	–	–	–	–	1.22
* Rawhide dust,	1	14.50	–	–	–	13.91	–	–	–	–	–	1.06	–	–	–	–	–	–	–	–	–	–	–
Raw wool,	1	6.95	7.54	–	–	12.88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3.63
Rotten brewers' grain,	1	78.77	–	–	–	.72	–	–	.04	–	–	.43	–	–	–	–	.26	.15	–	–	–	–	.59
Refuse from calico works,	1	4.07	–	–	–	4.28	–	–	–	–	–	11.95	–	–	–	–	–	–	–	–	–	–	–
* Refuse from glucose factory,	1	.13	–	–	–	–	–	–	–	–	–	42.76	–	2.88	39.88	–	38.78	–	2.92	3.00	–	–	–
* Refuse from glass factory,	1	16.48	–	–	–	–	–	–	19.50	–	–	–	–	–	–	6.12	–	–	–	–	–	–	–
Residue from water filter,	1	94.22	–	–	–	.12	–	–	–	–	–	.05	–	–	–	–	–	–	–	–	–	–	–
Rockweed, green,	1	68.50	23.70	–	–	.62	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

3. *Refuse Substances* — Concluded.

FERTILIZER MATERIALS.	Analyses.	Moisture.	Ash.	NITROGEN.			POTASH.			TOTAL PHOSPHORIC ACID.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
Rockweed, dry,	2	13.73	35.75	1.45	1.07	1.26	4.89	1.56	3.22	2.75	.14	1.44	–	–	–	5.97	4.88	.96	1.22	–	–	.16	–
* Salt marsh mud,	5	60.05	32.32	.28	.18	.24	–	–	.14	–	–	.08	–	–	–	–	.11	–	–	–	–	2.06	37.88
* Silt deposit,	1	7.15	–	–	–	1.14	–	–	.39	–	–	.25	–	–	–	–	.70	–	–	–	–	–	–
Sponge refuse,	1	7.25	–	–	–	2.43	–	–	–	–	–	3.19	–	–	–	–	3.94	1.27	–	–	–	–	39.05
* Sizing paste,	2	62.28	–	2.13	1.13	1.63	–	–	–	.34	.02	.18	–	–	–	–	–	–	–	–	–	–	–
* Sizing waste,	1	74.00	–	–	–	.01	–	–	.40	–	–	–	.01	–	–	–	–	–	–	–	–	–	1.43
Soap-grease refuse,	2	29.25	51.39	4.20	2.21	3.21	–	–	–	15.37	11.04	13.21	–	–	–	–	–	–	–	–	–	–	1.29
Soup from horse rendering,	1	92.14	–	–	–	1.12	–	–	–	–	–	.14	–	–	–	–	–	–	–	–	–	–	–
* Spent brewers' grain,	1	73.10	–	–	–	1.23	–	–	.07	–	–	.33	–	–	–	–	–	–	–	–	–	–	–
* Spent bone-black,	1	1.16	–	–	–	–	–	–	–	–	–	31.02	–	1.96	29.06	–	–	–	–	–	–	–	–
* Sugar-beet refuse,	1	7.70	–	–	–	6.39	–	–	9.72	–	–	–[1]	–	–	–	7.00	–[1]	–	–	2.82	–[1]	1.87	–
Sumac waste,	1	63.06	6.80	–	–	1.19	–	–	3.25	–	–	–	–	–	–	–	1.14	3.25	–	–	–	–	2.25
Starch waste from rubber factory,	1	10.01	.23	–	–	.02	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
* Sludge from sewage beds,	1	36.95	30.97	–	–	1.07	–	–	.20	–	–	.28	–	–	–	–	4.34	–	2.62	–	–	–	37.80
* Sludge from sewage-precipitating tanks.	4	37.74	–	1.31	.46	.91	.66	.07	.25	.86	.39	.61	–	–	–	–	3.10	2.19	8.55	.41	4.86	–	28.70
* Sewage,	4	54.11	72.89	1.04	.30	.55	.44	.09	.27	.42	.40	.63	–	–	–	–	–	2.79	–	–	–	.03	35.87

Salt mud,	2	53.37	41.19	.40	.39	.40	.33	.32	.33	–	–	–	–	–	–	.94	.91	.37	4.13	–	–	–	34.88
* Soot,	2	8.60	–	–	–	.77	1.57	.17	.87	.72	.23	.47	–	–	–	–	2.92	1.19	6.38	–	–	–	71.07
* Tankage,	76	8.02	–	11.27	4.11	5.88	–	–	–	21.62	.76	14.00	–	6.37	7.50	–	–	–	–	–	–	–	–
* Tobacco dust,	5	5.04	58.68	2.25	1.54	1.80	6.81	1.53	2.93	1.28	.36	.61	–	–	–	–	3.09	–	–	–	–	–	31.18
Tobacco leaves,	1	13.05	21.01	–	–	2.75	–	–	7.24	–	–	.43	–	–	–	–	4.17	2.17	.32	–	–	–	4.17
* Tobacco stems,	2	10.15	23.76	2.20	1.99	2.09	8.68	5.72	7.20	1.02	.32	.67	–	–	–	–	5.46	–	–	–	–	–	2.70
* Tobacco stalks exposed to the action of weather.	2	7.62	–	1.40	1.18	1.29	4.01	.52	2.26	.92	.38	.65	–	–	–	–	–	–	–	–	–	–	1.86
* Teopik fibre,	1	56.54	–	–	–	.53	–	–	1.26	–	–	.55	–	–	–	–	5.15	–	–	–	–	–	.75
Turf,	2	19.29	6.36	1.97	1.91	1.94	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
* Undried tankage,	1	29.00	–	–	–	1.06	–	–	–	–	–	3.51	–	2.94	.51	–	–	–	–	–	–	–	–
* Vegetable mould,	1	26.07	–	–	–	.62	–	–	.66	–	–	.45	–	–	–	–	–	–	–	–	–	–	–
* Wool dustings,	1	14.10	16.04	–	–	3.65	–	–	.29	–	–	.32	–	–	–	–	1.02	–	–	–	–	–	9.25
* Wool waste,	13	10.71	30.12	8.30	.39	3.05	5.92	.29	1.68	1.02	.05	.56	–	–	–	–	2.39	–	–	–	–	–	31.58
Wool washings, water,	1	–	–	–	–	–	–	–	3.92	–	–	–	–	–	–	.49	.28	–	–	–	–	–	–
* Wool waste and sheep manure,	1	7.13	–	–	–	2.63	–	–	2.20	–	–	.64	–	–	–	–	–	–	–	–	–	–	–
Wool washings, acid,	1	–	–	–	–	–	–	–	4.20	–	–	–	–	–	–	.40	.61	.20	–	–	–	–	–
Wool washings, alkaline,	1	92.03	3.28	–	–	.09	–	–	1.09	–	–	–	–	–	–	.92	.04	–	–	–	–	–	.22
Whale meat, raw,	1	44.50	1.04	–	–	4.86	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Waste from lactate factory,	1	34.11	–	–	–	.68	–	–	–	–	–	.67	–	–	–	–	22.59	–	–	–	–	–	6.92
* Whalebone scrapings,	1	6.90	–	–	–	13.01	–	–	–	–	–	.26	–	–	–	–	–	–	–	–	–	–	–
* Water abstract of dry forest leaves,	1	99.46	.16	–	–	.004	–	–	.03	–	–	.022	–	–	–	–	.025	–	–	–	–	–	–

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[1] None.

4. *Guanos, Phosphates, etc.*

FERTILIZER MATERIALS.	Analyses.	Moisture.	Ash.	NITROGEN.			POTASH.			TOTAL PHOSPHORIC ACID.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
* Acid phosphate,	44	10.61	–	–	–	–	–	–	–	19.16	11.60	15.75	9.53	3.87	2.35	–	–	–	–	–	–	–	–
* Apatite,	2	.07	–	–	–	–	–	–	–	37.74	32.62	35.18	–	2.09	33.09	–	–	–	–	–	–	–	–
* Belgian phosphate,	1	.21	–	–	–	–	–	–	–	–	–	9.54	–	–	–	–	41.27	–	–	–	–	–	–
* Bone ash,	1	.34	–	–	–	–	–	–	–	–	–	39.14	–	–	–	–	–	–	–	–	–	–	–
Bone-black,	5	4.60	–	–	–	–	–	–	–	30.54	16.56	28.28	–	–	–	–	–	–	–	–	–	–	3.64
Brockville phosphate,	1	2.50	–	–	–	–	–	–	–	–	–	35.21	–	–	–	–	–	–	–	–	–	–	6.46
Bat guano from Texas,	9	40.09	18.24	10.51	2.58	6.47	–	–	1.31	6.53	1.00	3.76	–	–	–	–	–	–	–	–	–	–	2.00
Bat guano from Florida,	2	15.66	–	–	–	9.74	–	–	1.77	3.44	3.26	3.35	–	–	–	–	–	–	–	–	–	–	19.33
* Bat guano from Havana, Cuba,	2	5.83	–	6.96	1.70	4.33	1.20	.53	.86	14.00	5.04	9.52	–	–	–	6.17	11.04	–	5.76	–	–	–	9.47
Cuban guano,	5	24.27	–	2.74	.63	1.67	–	–	–	16.16	11.54	13.35	–	–	–	–	–	–	–	–	–	–	3.17
Caribbean guano (orchilla),	12	7.31	–	–	–	–	–	–	–	35.43	18.11	26.77	–	–	–	–	39.95	3.29	–	2.68	–	–	1.27
* Dissolved bone-black,	38	11.60	–	–	–	–	–	–	–	20.93	15.60	17.56	12.98	3.40	1.18	–	–	–	–	–	–	–	–
* Double superphosphate,	2	6.27	–	–	–	–	–	–	–	50.14	45.42	47.78	18.36	20.97	8.45	–	–	–	–	–	–	–	–
* Dissolved bone meal,	9	6.47	–	4.64	1.66	2.14	–	–	–	22.26	14.58	16.42	3.95	8.45	4.02	–	–	–	–	–	–	–	–
* Damaraland guano,	1	17.70	–	–	–	5.79	–	–	3.53	–	–	14.78	4.90	5.79	4.09	7.03	14.21	2.05	–	5.94	–	5.77	9.26
* Florida rock phosphate,	2	.53	–	–	–	–	–	–	–	40.34	33.10	36.72	–	.10	36.62	–	–	–	–	–	–	–	–
* Florida soft phosphate,	1	4.46	–	–	–	–	–	–	–	–	–	26.48	–	.38	26.10	–	–	–	–	–	–	–	–
* Mona Island guano,	1	13.32	–	–	–	.76	–	–	–	–	–	21.88	–	7.55	14.33	–	37.49	–	–	–	–	–	2.45

* Novassa phosphate,	1	5.77	-	-	-	-	-	-	-	-	-	24.56	-	1.66	22.90	-	-	-	-	-	-	-	-
Odorless phosphate,	6	2.99	-	-	-	-	.52	.04	.38	21.74	18.40	19.54	-	.52	19.82	-	51.42	-	-	-	2.51	-	9.14
* Phosphatic slag,	9	.57	-	-	-	-	-	-	-	21.78	14.71	17.73	-	5.27	12.46	-	39.60	-	-	-	-	-	-
* Peruvian guano,	30	13.58	37.61	13.50	4.44	6.36	4.08	1.14	2.62	20.60	5.96	14.85	3.72	5.49	5.64	-	12.85	-	-	-	-	-	6.60
Rat guano from Florida,	1	10.32	-	-	-	3.32	-	-	6.85	-	-	2.30	-	-	-	-	-	-	-	-	-	-	1.15
* South Carolina rock phosphate,	5	.80	-	-	-	-	-	-	-	31.87	25.58	28.06	-	3.40	24.60	-	-	-	-	-	-	-	-
South Carolina floats,	1	.83	-	-	-	-	-	-	-	-	-	23.39	-	2.33	21.66	-	-	-	-	-	-	-	20.16
South American bone ash,	1	7.00	-	-	-	-	-	-	-	-	-	35.89	-	-	-	-	44.89	-	-	-	-	-	4.50
* Tennessee phosphate,	1	.37	-	-	-	-	-	-	.44	-	-	33.00	-	-	-	-	-	-	-	-	-	-	-
Upton phosphate,	1	9.07	-	-	-	-	-	-	-	-	-	40.15	-	37.84	2.31	-	-	-	-	-	-	-	-

5. *Animal Excrement, etc.*

* Barnyard manure,	38	73.38	8.29	.69	.18	.42	.92	.25	.53	.59	.10	.31	-	-	-	-	-	-	-	-	-	-	5.57
* Compost,	1	1.70	-	-	-	.79	-	-	.97	-	-	.56	-	-	-	-	-	-	-	-	-	-	-
Drainage from manure heap,	1	93.20	3.66	-	-	.98	-	-	.88	-	-	.24	-	-	-	-	-	-	-	-	-	-	-
Goose manure,	1	48.92	-	-	-	.21	-	-	.81	-	-	.95	-	-	-	-	-	-	-	-	-	-	-
* Guinea-pig manure,	1	8.35	-	-	-	1.74	-	-	1.66	-	-	.55	-	-	-	-	.39	-	-	-	-	-	3.78
* Hen manure,	4	43.21	-	1.83	.42	.87	2.96	.43	1.11	3.93	.63	1.62	-	-	-	-	1.19	.89	-	1.24	-	-	23.09
Hen-house refuse,	2	7.37	-	-	-	.71	-	-	1.03	-	-	1.02	-	-	-	-	-	-	-	-	-	-	71.07
Horse manure,	1	11.24	-	-	-	.74	-	-	2.82	-	-	1.46	-	-	-	-	-	-	-	-	-	-	12.60
* Liquid manure,	1	96.56	-	-	-	.56	-	-	.02	-	-	.01	-	-	-	-	-	-	-	-	-	-	-
Poudrette, dry,	1	5.25	35.45	-	-	3.58	-	-	.49	-	-	5.74	-	-	-	-	-	-	-	-	-	-	4.65
* Sheep manure,	10	8.33	17.60	2.97	.85	2.19	3.42	.68	2.13	2.24	.22	1.46	-	-	-	-	3.36	-	-	-	-	-	28.49

6. *Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds.*

FERTILIZER MATERIALS.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
1. Chemicals, Refuse Salts, etc.													
*Carbonate of potash, high grade,	67.6	–	–	1,218.4	–	–	–	–	–	–	–	–	–
*Carbonate of potash,	364.4	–	–	384.8	–	–	–	390.4	–	–	–	–	7.8
Carnalite,	–	–	–	274	–	153	–	264	–	11	–	831	–
*Kainit,	63.6	–	–	249.4	–	379.4	47.4	127.4	–	405	–	412.8	42.6
Krugite,	96	–	–	168	–	105	249	176	–	639	–	133	299
*Muriate of potash,	31.2	–	–	997.8	–	133.8	–	11	–	–	–	976	14
*Nitrate of potash,	19.6	–	266	891.4	–	–	–	–	–	–	–	–	–
*Nitrate of soda,	30.4	–	309.4	–	–	710	–	–	–	–	–	10	10
*Nitre lime,	18.4	–	168.4	–	–	–	586	–	–	–	–	–	45.6
Nitre salt cake,	121	–	46	17	–	591	–	–	–	955	–	–	78
Phosphate of potash,	75	–	–	651	750	–	–	–	–	269	–	–	18
Phosphate of ammonia,	121	–	207	–	877	–	–	–	–	249	–	–	16
*Potash refuse from manufacture of cyanide of potash,	785	–	19	147	–	–	–	–	–	–	–	–	–
*Sulfate of ammonia,	19.8	–	414.8	–	–	–	–	–	–	1,200	–	–	–

*Sulfate of potash,	16.4	–	–	985	–	89.2	–	30	–	914.4	–	–	.15
*Sulfate of potash-magnesium,	76.6	–	–	506.8	–	125	51.4	277.2	–	894.4	–	39	45.2
*Silicate of potash,	157.2	–	–	411.8	–	–	–	–	–	–	–	–	–
*Sulfate of magnesia,	475	–	–	–	–	–	56	348	–	722	–	–	115
*Sulfate of soda,	28	–	–	–	–	–	–	–	–	1,189	–	–	–
Saltpetre waste,	51	–	44	273	–	741	15	4	–	37	–	925	–
*Vegetable potash,	72.6	–	–	519	51	–	413	–	–	–	–	–	194
2. *Ashes, Marls, Lime Compounds, etc.*													
Acetylene gas-tank refuse,	84	–	–	–	–	–	1,183	–	–	–	–	–	–
Ashes of spent tan bark,	97	–	–	36	27	–	622	68	36	–	–	–	504
Ashes from cremation of swill,	97	–	–	79	283	–	672	37	93	–	–	–	431
Ashes from blue works,	243	1,276	–	180	–	–	–	–	–	–	–	–	246
*Ashes from cremation of garbage,	60	–	–	103	175	313	404	23	184	91	217	95	568
*Ashes from hay and straw,	8	–	–	31	20	–	104	–	–	–	–	–	1,327
*Ashes from jute waste,	4	–	–	10	11	77	121	8	152	–	–	11	1,620
*Ashes from peach-tree trimmings,	11	–	–	98	49	151	375	–	210	44	–	–	271
*Ashes from soft coal and sawdust,	67.2	–	–	14.6	14.8	–	56	–	–	–	–	–	1,390.6
Ammoniated marl,	66	–	32	–	208	–	–	–	–	–	–	–	–
*Bleachery refuse,	84	–	–	16	–	234	716	–	–	–	–	–	462
Bituminous coal ashes,	73	–	–	8	9	–	38	–	–	–	–	–	1,483
*Brick-yard ashes,	11.6	–	–	69	29.4	–	486.6	–	–	–	–	–	952.6
*Coal and wood ashes,	26.4	–	–	8.80	23	–	47.8	–	–	–	–	–	1,618.8

6. *Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds* — Continued.

FERTILIZER MATERIALS.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
2. *Ashes, Marls, Lime Compounds, etc.* — Con.													
* Cotton-seed hull ashes,	146.2	–	–	450.6	169.8	–	160.6	252.8	–	–	–	–	342.4
* Corn-cob ashes,	109.4	–	23.6	494.6	94.4	–	140	–	25.6	–	–	–	762.4
* Carbonate of lime,	9	–	–	–	–	–	1,046.2	–	–	–	–	–	–
Gypse,	33	–	–	–	–	–	1,017	–	–	–	–	–	57
Gas-house lime,	223.2	–	–	–	–	–	963.8	166	–	393.2	–	–	179.8
Green sand marl (Virginia),	25	–	–	23	187	–	516	–	103	–	–	–	826
* Hemp ashes,	– 1	–	–	49.6	34.8	–	1,209.4	–	–	–	–	–	63.8
Hard-pine wood ashes,	15	–	–	203	45	–	499	–	–	–	–	–	598
* Lime refuse from soda factory,	481	–	–	–	–	–	297	–	27	463	–	–	33
Lime waste from sugar factory,	726	–	–	4	45	–	550	–	–	–	–	–	6
Lime,	–	–	–	–	–	–	1,873	–	–	–	–	–	27
* Lime-kiln ashes,	227	–	–	40.8	15.6	–	829.8	26	–	–	–	–	135.6
* Leather-scrap ashes,	118.8	–	3	44.6	57.8	–	156	–	–	–	–	–	921.6
Logwood ashes,	30	–	–	2	46	–	78	–	–	–	–	–	194

Mill ashes,	11	–	–	32	9	–	699	27	–	–	–	–	727
Magnolia ashes (Florida),	32	–	–	51	9	–	–	–	–	–	–	–	122
Massachusetts marls,	274	–	–	5	21	–	810	13	14	–	571	–	69
* Marl,	310.8	–	.02	5.80	.40	–	–[2]	–	–	–	–	–	–
Marl (North Carolina),	14	–	–	1	11	–	439	12	–	–	–	–	1,004
* Nova Scotia plaster (gypsum),	129	–	–	–	–	–	675	15	–	897	–	–	116
Olive earth (Virginia),	39	–	–	5	275	–	383	–	120	–	–	–	1,011
Onondaga plaster (New York gypsum),	265	–	–	–	–	–	600	93	–	650	164	–	197
* Oyster-shell lime,	–[1]	–	–	–	7.60	–	1,110.8	–	–	–	189	–	176.4
* Picker-waste ashes,	6	–	–	131	24	–	–	–	–	–	–	–	1,269
* Patent-process lime,	–[1]	–	–	–	–	–	1,157.4	–	–	–	–	–	180.6
Peat ashes,	93	–	–	9	2	–	46	33	123	–	–	–	903
* Prepared lime,	–[1]	–	–	–	–	79.8	1,389.6	10	31	–	–	–	–
* Pine-wood ashes,	55.2	–	–	87.4	61.4	–	472.2	–	–	–	–	–	749.2
* Peat,	906	409.4	18.4	.8	1.6	–	17.6	–	–	–	–	–	324.6
* Plastering,	144	–	–	–	4.40	–	2.30	–	–	–	–	–	13.30
* Pulp ashes,	–[1]	–	–	9.2	2.4	–	1,354.4	–	–	–	–	–	140
Railroad-tie ashes,	94	–	–	18	11	–	50	–	–	–	–	–	1,604
* Refuse ashes from sawdust,	278.4	–	–	71.6	154.4	–	695.2	–	–	–	–	–	505.4
Sea-weed ashes,	29	–	–	18	6	175	121	87	–	60	–	132	1,273
* Tan-bark ashes,	30	–	–	10.4	15.4	–	485.8	–	–	–	–	–	270.8

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[1] None.

[2] Trace.

6. Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds — Continued.

FERTILIZER MATERIALS.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
2. *Ashes, Marls, Lime Compounds, etc.* — Con.													
Virginia marls,	320	–	–	10	2	–	145	4	–	13	145	–	1,285
* Waste lime,	16	–	–	–	–	–	1,482	–	–	–	–	–	8
* Waste lime from tannery,	17.6	–	13.13	–	–	–	1,083.6	–	–	–	–	–	76.6
* Walnut-wood ashes,	75.8	–	–	101.2	41.4	–	814.6	–	–	–	–	–	45.8
* Wood ashes,	241.6	–	–	184	28.4	–	659.6	66.2	148.6	–	–	–	330.2
* Wool-waste ashes,	168	–	–	544.8	5.2	–	57.6	–	–	–	–	–	556.4
* Wood charcoal,	73	–	–	8	3.2	–	–	–	–	–	–	–	31.6
3. *Refuse Substances.*													
Ammoniate,	118	–	227	–	69	–	–	–	–	–	–	–	28
* Blood and bone,	119	–	125	–	243	–	–	–	–	–	–	–	–
Bone soup,	1,658	141	23	–	25	–	–	–	–	–	–	–	–
* Bone from fish,	176	–	96	–	471	–	–	–	–	–	–	–	–
* Broom-corn seed,	148	–	30	10	11	–	–	–	–	–	–	–	–
* Bone dust,	101	–	61.2	–	356	–	–	–	–	–	–	–	–

* Banana skins,	280	–	5	109	36	–	–	–	–	–	–	–	–
Blue-green algæ (*Lyngbia majuscula*),	325	–	85	16	4	71	41	24	–	–	–	–	111
* Burned bone,	41.2	–	–	–	746.6	–	1,042.4	–	–	–	–	–	19.2
* Cassava waste,	180.6	–	6.60	5.60	1.20	–	12.20	–	–	–	–	–	–
* Coral formation,	785.2	–	5.6	2.8	4.2	–	462.8	27.8	–	–	–	–	339.6
* Cocoanut-fibre pith,	124	75.60	6.80	16.80	.06	–	11.4	–	–	–	–	–	20.2
* Cotton compost,	850.2	–	18.6	11.2	7.8	–	–	–	–	–	–	–	–
* Cotton-seed dust,	87.6	–	24.4	29.6	10.8	–	29.6	–	–	–	–	–	–
* Cotton-seed droppings,	81.6	–	19.2	37	4	–	13.2	–	–	–	–	–	–
* Cocoa shells,	77.6	–	46.6	49.6	7.2	–	15.2	–	–	–	–	–	–
* Cotton waste, dry,	129	271.4	20.6	–	6.4	–	34.6	–	–	–	–	–	292.2
* Concentrated wool washings,	823	–	22	203	2	–	–	–	–	–	–	–	–
* Condensed bone steam,	1,635	–	39	–	1	–	–	–	–	–	–	–	–
* Castor-bean pomace,	157.2	114	103.6	24	42.4	–	17.4	6.8	–	–	–	–	35
* Cotton-seed meal,	137	–	134.8	32.8	51.2	–	–	–	–	–	–	–	5.6
* Cork dust,	15	–	12	7	2	–	15	2	–	–	–	–	5
* Cotton waste, wet,	480.4	688.4	24.2	12.8	13	–	54.6	–	–	–	–	–	763.2
Cotton dust,	654	1,019	16	9	6	–	–	–	–	–	–	–	844
Dried soup from meat and bone,	296	168	199	–	11	–	–	–	–	–	–	–	13
Dried soup from rendering cattle feet,	216	150	289	–	9	–	–	–	–	–	–	–	5
* Dried blood,	209	–	203.2	–	50	–	–	–	–	–	–	–	–
* Dry ground fish,	177.4	–	167.2	–	177.4	–	–	–	–	–	–	–	–

6. Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds — Continued.

FERTILIZER MATERIALS.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
3. *Refuse Substances* — Con.													
* Damaged grain,	843	–	29	6	11	–	–	–	–	–	–	–	–
* Deposit from Charles River,	429	–	19	12	15	–	36	–	–	–	–	–	885
* Dredgings from Cape Cod,	380	–	20	3	1	–	–	–	41	–	–	11	–
* Deposit from pond,	80	–	8	5	6	–	12	–	–	–	–	–	–
Eel grass,	708	312	17	18	6	33	43	2	–	–	–	–	21
Felt refuse,	585	671	105	–	–	–	–	–	–	–	–	–	–
* Fleshings,	139	863	151	–	6	–	–	–	–	–	–	–	–
* Fresh-cut bone,	500	–	60	–	337	–	–	–	–	–	–	–	–
* Factory waste,	262.2	644	31	71.4	12	–	260.4	–	–	134.6	–	–	122.8
* Fibre waste,	1,230.6	–	4.4	9.8	2	–	7.2	–	–	–	–	–	11.6
Fish with 20 to 40 per cent. water,	604	412	119	–	142	–	–	–	–	–	–	–	34
Fish with more than 40 per cent. water,	909	310	99	–	112	–	–	–	–	–	–	–	27
Fresh-water mud,	807	–	27	4	5	–	25	6	36	–	–	–	365
* Garbage tankage,	42.4	–	119	–	121.2	–	–	–	–	–	–	–	–

* Ground bone, damaged by salt water,	656.2	-	35.6	-	344.2	-	-	-	-	-	-	-	-
* Ground tobacco stems,	177	404	40	123	12	-	135	-	-	-	-	-	26
* Ground bones,	120.6	1,282.8	61.2	-	486.8	-	-	-	-	-	-	-	21.6
Glucose refuse,	162	-	52	3	6	-	4	4	-	-	-	-	1
German peat moss,	190	22.8	14.4	1.2	1	-	4.2	-	-	-	-	-	7.2
Horn shavings,	97	-	306	-	8	-	-	-	-	-	-	-	-
* Horn dust,	172.6	-	292	-	.8	-	-	-	-	-	-	-	-
* Hoof meal,	82	-	304	-	15	-	-	-	-	-	-	-	-
Horn and hoof waste,	203	153	265	-	37	-	-	-	-	-	-	-	5
* Hair waste,	130	455	184	3	10	82	-	-	-	-	-	-	-
* Hop refuse,	1,691	34	12	1	2	-	-	-	-	-	-	-	17
Ivory dust,	230	1,053	133	-	491	-	-	-	-	-	-	-	-
* Jadoo fibre,	204	232	17.4	8.6	15	-	70	-	-	-	-	-	81
Jute waste,	262	-	30	2	14	-	-	-	-	-	-	-	-
* Kiln dust from brewery,	194	-	86	43	19	-	16	-	-	-	-	-	142
* Linseed meal,	173	-	115.6	30.4	29.4	-	-	-	-	-	-	-	11.6
Lobster shells,	145	-	90	-	70	-	445	26	-	-	-	-	5
* Meat meal,	64	171	185	-	62	-	-	-	-	-	-	-	-
Meat mass,	242	272	209	-	41	-	-	-	-	-	-	-	12
Meat scrap,	496	-	127	-	116	-	-	-	-	-	-	-	-
Morocco factory waste,	454	-	23	7	51	-	392	-	-	25	-	-	483
* Meat and bone,	172.8	-	105.8	-	336.2	-	-	-	-	-	-	-	-

6. Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds — Continued.

FERTILIZER MATERIALS.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
3. *Refuse Substances* — Con.													
* Mill waste,	90	-	26.8	11.6	21.4	-	-	-	-	-	-	-	-
Mill sweepings,	190	-	75	13	24	-	-	-	-	-	-	-	100
* Milk cassein,	143	-	146	15.2	161.2	-	235.6	-	28	-	-	-	2
Madder,	239	-	18	48	7	-	79	10	-	-	-	-	93
Mussel mud, wet,	1,200	546	4	123	2	14	19	3	70	-	-	-	-
Mussel mud, dry,	45	1,440	14	-	7	-	468	-	165	-	-	-	752
* Muck and peat, wet,	1,351.6	199.4	9.2	1	1.2	-	7.40	-	-	-	-	-	134.6
* Muck and peat, dry,	133	1,391	17	-	6	-	15	-	-	-	-	-	-
* Mud,	840.4	895.2	7	3	4	-	1.8	-	-	-	-	-	-
Oleomargarine refuse,	171	288	242	-	18	-	-	-	-	-	-	-	19
* Paper-mill dustings,	133.6	468.2	7	12	2.6	-	6	-	-	88	-	-	284.6
* Product from garbage plant,	83	51	-	10	138	-	-	-	-	-	-	-	330
Pine barren grass,	170	48	3	1	4	-	-	-	-	-	-	-	33
Pine needles,	190	68	9	1	2	-	-	-	-	-	-	-	24

Raw wool,	139	151	258	-	-	-	-	-	-	-	-	-	73
*Rawhide dust,	290	-	278.2	-	21.2	-	-	-	-	-	-	-	-
Rotten brewers' grain,	1,575	-	14	1	9	-	5	3	-	-	-	-	12
Refuse from calico works,	81	-	86	-	239	-	-	-	-	-	-	-	-
*Refuse from glucose factory,	3	-	-	-	855	-	776	-	58	60	-	-	-
*Refuse from glass factory,	330	-	-	390	-	122	-	-	-	-	-	-	-
Rockweed, green,	1,370	474	12	-	-	-	-	-	-	-	-	-	-
Rockweed, dry,	274.6	715	25.2	64.4	28.8	119.4	97.6	19.2	24.4	-	-	3.2	-
Residue from water filter,	1,884	-	2	-	1	-	-	-	-	-	-	-	-
*Silt deposit,	143	-	22.8	7.8	5	-	14	-	-	-	-	-	-
Sponge refuse,	145	-	49	-	64	-	79	25	-	-	-	-	781
*Sizing paste,	1,245.6	-	32.6	3.6	-	-	-	-	-	-	-	-	-
*Sizing waste,	1,480	-	.2	8	.2	-	-	-	-	-	-	-	29
*Sludge from sewage beds,	739	619.4	21.4	4	5.6	-	86.8	-	52.4	-	-	-	75.6
Soap-grease refuse,	585	1,028	22	-	3	-	-	-	-	-	-	-	26
Soup from horse rendering,	1,462	-	24.6	1.4	6.6	-	-	-	-	-	-	-	-
*Spent brewers' grain,	1,842.8	-	22.4	2.8	-	-	-	-	-	-	-	-	-
*Spent bone-black,	23	-	-	-	620	-	-	-	-	-	-	-	-
*Sugar-beet refuse,	154	-	127.8	194.4	-[1]	140	-[1]	-	-	56.4	-[1]	37.4	-
Sumac waste,	1,261	136	24	65	-	-	23	65	-	-	-	-	45
Starch waste from rubber factory,	200	5	.4	-	-	-	-	-	-	-	-	-	-

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[1] None.

6. *Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds* — Continued.

FERTILIZER MATERIALS.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
3. *Refuse Substances* — Con.													
* Sludge from sewage-precipitating tanks,	755	-	18	5	12	-	62	44	171	8	97	-	574
* Sewage,	1,082.2	1,452.8	11	5.4	12.6	-	-	-	55.8	-	-	6.6	617.4
Salt mud,	1,067	824	8	7	-	19	18	7	83	-	-	-	698
* Salt marsh mud,	1,201	646.4	4.8	2.8	1.6	-	2.2	-	-	-	-	41.2	757.6
* Soot,	172	-	15	17	9	-	58	24	128	-	-	-	1,421
* Tankage,	160.4	-	117.6	-	28.0	-	-	-	-	-	-	-	-
* Tobacco dust,	100.8	1,173.6	36	58.6	12.2	-	61.8	-	-	-	-	-	623.6
* Tobacco stems,	203	475.2	41.8	144	13.4	-	109.2	-	-	-	-	-	54
Tobacco leaves,	261	420	55	145	9	-	83	43	6	-	-	-	83
* Tobacco stalks exposed to the action of weather,	152.4	-	25.8	45.2	13	-	-	-	-	-	-	-	37.2
* Teopik fibre,	1,131	-	11	25	11	-	103	-	-	-	-	-	15
Turf,	386	127	39	-	-	-	-	-	-	-	-	-	-
* Undried tankage,	580	-	21	-	70	-	-	-	-	-	-	-	-
* Wool waste,	214.2	602.4	61	33.6	11.2	-	47.8	-	-	-	-	-	601.6

* Wool dustings,	282	320.8	73	5.8	6.4	–	20.4	–	–	–	–	–	185
Wool washings, water,	–	–	–	7.8	–	10	6	–	–	–	–	–	–
Wool washings, acid,	–	–	–	8.4	–	8	12	.4	–	–	–	–	–
Wool washings, alkaline,	1,841	66	2	22	–	18	1	–	–	–	–	–	4
Whale meat, raw,	890	21	9.7	–	–	–	–	–	–	–	–	–	–
* Wool waste and sheep manure,	142.6	–	52.6	44	12.8	–	–	–	–	–	–	–	–
Waste from lactate factory,	682	–	14	–	13	–	452	–	–	–	–	–	138
* Whalebone scrapings,	14	–	260	–	5	–	–	–	–	–	–	–	–
* Water abstract of dry forest leaves,	1,989	3	.08	.6	.44	–	.5	–	–	–	–	–	–
Vegetable mould,	521.4	–	12.4	13.2	9	–	–	–	–	–	–	–	–
4. Guanos, Phosphates, etc.													
* Acid phosphate,	212.2	–	–	–	315	–	–	–	–	–	–	–	–
* Apatite,	1	–	–	–	704	–	–	–	–	–	–	–	–
* Bone ash,	7	–	–	–	783	–	–	–	–	–	–	–	–
* Belgian phosphate,	4.2	–	–	–	190.8	–	825.4	–	–	–	–	–	–
Bone-black,	92	–	–	–	566	–	–	–	–	–	–	–	73
Brockville phosphate,	5.0	–	–	–	70.4	–	–	–	–	–	–	–	129
Bat guano from Texas,	80.2	365	129	26	75	–	–	–	–	–	–	–	40
Bat guano from Florida,	313	–	195	35	67	–	–	–	–	–	–	–	387
* Bat guano from Havana, Cuba,	116.6	–	86.6	17.2	90.4	123.4	220.8	–	115.2	–	–	–	189.4
Cuban guano,	485	–	33	–	267	–	–	–	–	–	–	–	63
Caribbean guano (orchilla),	146	–	–	–	535	–	799	66	–	54	–	–	25

6. *Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds* — Concluded.

FERTILIZER MATERIALS.	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
4. Guanos, Phosphates, etc. — Con.													
* Dissolved bone-black,	232	–	–	–	351.2	–	–	–	–	–	–	–	–
* Double superphosphate,	125	–	–	–	956	–	–	–	–	–	–	–	–
* Dissolved bone meal,	129.4	–	428	–	328.4	–	–	–	–	–	–	–	–
* Damaraland guano,	354	–	116	71	296	141	284	41	–	119	–	115	185
* Florida rock phosphate,	11	–	–	–	734	–	–	–	–	–	–	–	–
* Florida soft phosphate,	89	–	–	–	530	–	–	–	–	–	–	–	–
* Mona Island guano,	266	–	15	–	438	–	750	–	–	–	–	–	49
* Novassa phosphate,	115	–	–	–	491	–	–	–	–	–	–	–	–
Odorless phosphate,	60	–	–	8	391	–	1,028	–	–	–	50	–	183
* Phosphatic slag,	11.4	–	–	–	354.6	–	792	–	–	–	–	–	–
Peruvian guano,	271.6	752.2	127.2	52.4	247	–	257	–	–	–	–	–	132
Rat guano from Florida,	206	–	66	137	46	–	–	–	–	–	–	–	23
* South Carolina rock phosphate,	16	–	–	–	561.2	–	–	–	–	–	–	–	–
South Carolina floats,	17	–	–	–	468	–	–	–	–	–	–	–	403

South American bone ash,	14.0	–	–	–	718	–	898	–	–	–	–	–	90
*Tennessee phosphate,	7	–	–	9	660	–	–	–	–	–	–	–	–
Upton phosphate,	181	–	–	–	803	–	–	–	–	–	–	–	–
5. Animal Excrement, etc.													
*Barnyard manure,	1,466.6	165.8	8.4	10.6	6.2	–	–	–	–	–	–	–	111.4
*Compost,	34	–	15.8	19.4	11.2	–	–	–	–	–	–	–	–
Drainage from manure heap,	1,864	73	19.6	17.6	48	–	–	–	–	–	–	–	–
Goose manure,	978	–	4.2	16.2	19	–	–	–	–	–	–	–	–
*Hen manure,	864.2	–	17.4	22.2	32.4	–	238	17.8	–	24.8	–	–	461.8
Hen-house refuse,	147	–	14.2	20.6	20.4	–	–	–	–	–	–	–	1,421
Horse manure,	225	–	14.8	56.4	29.2	–	–	–	–	–	–	–	252
Guinea-pig manure,	167	–	34.8	33.2	11	–	7.8	–	–	–	–	–	75.6
*Liquid manure,	1,931.2	–	11.2	.4	.2	–	–	–	–	–	–	–	–
Poudrette, dry,	105	709	71.6	9.8	115	–	–	–	–	–	–	–	93
*Sheep manure,	166.6	352	43.8	42.6	29.2	–	67.2	–	–	–	–	–	569.8

COMPILATION OF ANALYSES OF FRUITS, GARDEN CROPS AND INSECTICIDES.

H. D. HASKINS.

1. Analyses of fruits.
2. Analyses of garden crops.
3. Relative proportions of phosphoric acid, potassium oxide and nitrogen in fruits and garden crops.
4. Analyses of insecticides.

The results of chemical analyses of twenty prominent garden crops (green) show the following average composition, expressed in parts per thousand: —

Nitrogen,	4.1
Potassium oxide,	3.9
Phosphoric acid,	1.9

A computation of the results of the above analyses of green garden vegetables shows the following relative proportion of the three essential ingredients of plant food: —

Nitrogen,	2.2
Potassium oxide,	2.0
Phosphoric acid,	1.0

The weight and particular stage of growth of the vegetables when harvested control, under otherwise corresponding conditions, the actual consumption of each of these articles of plant food. Our information regarding these points is still too fragmentary to enable a more detailed statement here beyond relative proportions. It must suffice for the present to call attention to the fact that a liberal manuring within reasonable limits pays, as a rule, better than a scanty one. (C. A. GOESSMANN.)

1. ANALYSES OF FRUITS.

Fertilizing Constituents of Fruits (Parts per Thousand).

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Ericaceæ: —										
* Cranberries,	996	–	1.8	.9	.1	.3	.1	.3	–	–
* Cranberries,	894	.8	–	1.0	–	.2	.1	.3	–	–
Rosaceæ: —										
Apples,	831	.6	2.2	.8	.6	.1	.2	.3	.1	–
* Apples,	799	1.3	4.1	1.9	.3	.3	.3	.1	–	–
* Peaches,	884	–	3.4	2.5	–	.1	.2	.5	–	–
Pears,	831	.6	3.3	1.8	.3	.3	.2	.5	.2	–
Strawberries,	902	–	3.3	.7	.9	.5	–	.5	.1	.1
* Strawberries,	–	–	5.2	2.6	.2	.7	.4	1.0	–	–

Fertilizing Constituents of Fruits — Concluded.

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Rosaceæ — *Con.*										
* Strawberry vines,	–	–	33.4	3.5	4.5	12.2	1.3	4.8	–	–
Cherries,	825	–	3.9	2.0	.1	.3	.2	.6	.2	.1
Plums,	838	–	2.9	1.7	–	.3	.2	.4	.1	–
Saxifragaceæ: —										
* Currants, white,	–	–	5.9	3.1	.2	1.0	.3	1.1	–	–
* Currants, red,	871	–	4.1	1.9	.2	.8	.3	.9	–	–
Gooseberries,	903	–	3.3	1.3	.3	.4	.2	.7	–	–
Viticeæ: —										
Grapes,	830	1.7	8.8	5.0	.1	1.0	.4	1.4	.5	.1
Grape seed,	110	19.0	22.7	6.9	.5	5.6	1.4	7.0	.8	.1

2. Analyses of Garden Crops.

Fertilizing Constituents of Garden Crops (Parts per Thousand).

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Chenopodiaceæ: —										
Mangolds,	880	1.8	9.1	4.8	1.5	.3	.4	.8	.3	.9
* Mangolds,	873	1.9	12.2	3.8	1.3	.6	.4	.9	–	–
Mangold leaves,	905	3.0	14.6	4.5	2.8	1.6	1.4	1.0	.8	2.3
Sugar beets,	805	1.6	7.1	3.8	.6	.4	.6	.9	.3	.3
* Sugar beets,	869	2.2	10.4	4.8	.8	.6	.4	1.0	.1	–
Sugar beet tops,	840	2.0	9.6	2.8	2.3	.9	1.1	1.2	.2	.3
Sugar beet leaves,	897	3.0	15.3	4.0	2.0	3.1	1.7	.7	.8	1.3
Sugar beet seed,	146	–	45.3	11.1	4.2	10.2	7.3	7.5	2.0	1.9
* Red beets,	877	2.4	11.3	4.4	.9	.5	.3	.9	–	–

Fertilizing Constituents of Garden Crops — Continued.

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Chenopodiaceæ — *Con.*										
Spinach,	903	2.4	16.0	2.7	5.7	1.9	1.0	1.6	1.1	1.0
* Spinach,	922	3.4	9.6	9.6	2.1	.6	.5	.5	–	–
Compositæ: —										
Lettuce, common,	940	–	8.1	3.7	.8	.5	.2	.7	.3	.4
Head lettuce,	943	2.2	10.3	3.9	.8	1.5	.6	1.0	.4	.8
* Head lettuce,	970	1.2	–	2.3	.2	.3	.1	.3	–	–
Roman lettuce,	925	2.0	9.8	2.5	3.5	1.2	.4	1.1	.4	.4
Artichoke,	811	–	10.1	2.4	.7	1.0	.4	3.9	.5	.2
* Artichoke, Jerusalem,	775	4.6	–	4.8	–	–	–	1.7	–	–

Convolvulaceæ: —										
Sweet potato,	758	2.4	7.4	3.7	.5	.7	.3	.8	.4	.9
Cruciferæ: —										
White turnips,	920	1.8	6.4	2.9	.6	.7	.2	.8	.7	.3
* White turnips,	895	1.8	10.1	3.9	.8	.9	.3	1.0	1.0	–
White turnip leaves,	898	3.0	11.9	2.8	1.1	3.9	.5	.9	1.1	1.2
* Ruta-bagas,	891	1.9	10.6	4.9	.7	.9	.3	1.2	–	–
Savoy cabbage,	871	5.3	14.0	3.9	1.4	3.0	.5	2.1	1.2	1.1
White cabbage,	900	3.0	9.6	4.3	.8	1.2	.4	1.1	1.3	.5
* White cabbage,	984	2.3	–	3.4	.3	.2	.1	.2	–	–
Cabbage leaves,	890	2.4	15.6	5.8	1.5	2.8	.6	1.4	2.4	1.3
Cauliflower,	904	4.0	8.0	3.6	.5	.5	.3	1.6	1.0	.3
Horse-radish,	767	4.3	19.7	7.7	.4	2.0	.4	2.0	4.9	.3
Radishes,	933	1.9	4.9	1.6	1.0	.7	.2	4.5	.3	.5
Kohlrabi,	850	4.8	12.3	4.3	.8	.4	.8	2.7	1.1	.6

Fertilizing Constituents of Garden Crops — Continued.

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Cucurbitaceæ : —										
Cucumbers, ...	956	1.6	5.8	2.4	.6	.4	.2	1.2	.4	.4
Pumpkins, ...	900	1.1	4.4	.9	.9	.3	.2	.7	.3	.4
Gramineæ : —										
Corn, whole plant, green, . . .	829	1.9	10.4	3.7	.5	1.4	1.1	1.0	.3	.5
* Corn, whole plant, green, . . .	786	4.1	–	3.8	.5	1.5	.9	1.5	–	–
Corn, kernels, ...	144	16.0	12.4	3.7	.1	.3	1.9	5.7	.1	.2
* Corn, kernels, ...	100	18.2	–	4.0	.3	.3	2.1	7.0	–	–
* Corn, whole ears, ...	90	14.1	–	4.7	.6	.2	1.8	5.7	–	–
* Corn stover, ...	282	11.2	37.4	13.2	7.9	5.2	2.6	3.0	–	–

Leguminosæ : —										
Hay of peas cut green, ...	167	22.9	62.4	23.2	2.3	15.6	6.3	6.8	5.1	2.0
* Cow-pea (*Dolichos*), green, ...	788	2.9	–	3.1	.6	3.0	1.0	1.0	–	–
* Small pea (*Lathyrus Sylvestris*), dry, .	90	38.5	–	25.7	4.7	17.9	5.0	9.0	–	–
Peas, seed, ...	143	35.8	23.4	10.1	.2	1.1	1.9	8.4	.8	.4
Pea straw, ...	160	10.4	43.1	9.9	1.8	15.9	3.5	3.5	2.7	2.3
Garden beans, seed, ...	150	39.0	27.4	12.1	.4	1.5	2.1	9.7	1.1	.3
Bean straw, ...	166	–	40.2	12.8	3.2	11.1	2.5	3.9	1.7	3.1
* Velvet beans, kernel, ...	111.6	31.1	–	13.2	–	–	–	7.7	–	–
* Velvet beans, with pod, ...	115.2	19.6	–	13.1	–	–	–	8.4	–	–
* Leaves and stems of velvet beans, . .	58.8	28.6	–	–	–	–	–	–	–	–
Liliaceæ : —										
* Asparagus, ...	942	3.3	–	3.29	–	–	–	1.08	–	–
Asparagus, ...	933	3.2	5.0	1.2	.9	.6	.2	.9	.3	.3

Fertilizing Constituents of Garden Crops — Concluded.

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Liliaceæ — *Con.*										
Onions, ...	860	2.7	7.4	2.5	.2	1.6	.3	1.3	.4	.2
* Onions, ...	892	–	4.9	1.8	.1	.4	.2	.7	–	–
Solanaceæ: —										
Potatoes, ...	750	3.4	9.5	5.8	.3	.3	.5	1.6	.6	.3
* Potatoes, ...	798	2.1	9.9	2.9	.1	.1	.2	.7	–	–
Potato tops, nearly ripe, ...	770	4.9	19.7	4.3	.4	6.4	3.3	1.6	1.3	1.1
Potato tops, unripe, ...	825	6.3	16.5	4.4	.3	5.1	2.4	1.2	.8	.9
* Tomatoes, ...	940	1.7	–	3.6	–	.3	.2	.4	–	–
Tobacco leaves, ...	180	34.8	140.7	40.7	4.5	50.7	10.4	6.6	8.5	9.4

* Tobacco, whole leaf,	103.1	24.3	–	57.9	24.7	45.8	13.8	4.3	16.3	1.59
Tobacco stalks,	180	24.6	64.7	28.2	6.6	12.4	.5	9.2	2.2	2.4
* Tobacco stems,	106	22.9	140.7	64.6	3.4	38.9	12.3	6.0	–	–
Umbelliferæ: —										
Carrots,	850	2.2	8.2	3.0	1.7	.9	.4	1.1	.5	.4
* Carrots,	898	1.5	9.2	5.1	.6	.7	.2	.9	–	–
Carrot tops,	822	5.1	23.9	2.9	4.7	7.9	.8	1.0	1.8	2.4
Carrot tops, dry,	98	31.3	125.2	48.8	40.3	20.9	6.7	6.1	–	–
Parsnips,	793	5.4	10.0	.4	.2	1.1	.6	1.9	.5	.4
* Parsnips,	803	2.2	–	6.2	.1	.9	.5	1.9	–	–
Celery,	841	2.4	17.6	7.6	–	2.3	1.0	2.2	1.0	2.8

Many of the foregoing analyses were compiled from the tables of E. Wolff. Those marked with a star (*) are from analyses made at the Massachusetts State Agricultural Experiment Station, Amherst, Mass., and since 1895, at the chemical division of the Hatch Experiment Station of the Massachusetts Agricultural College.

3. Relative Proportions of Phosphoric Acid, Potassium Oxide and Nitrogen in Fruits and Garden Crops.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Fruits.			
Ericaceæ: —			
* Cranberries, ...	1	3.0	–
* Cranberries, ...	1	3.33	2.66
Rosaceæ: —			
Apples, ...	1	2.7	2.0
* Apples, ...	1	1.9	1.3
* Peaches, ...	1	1.3	–
Pears, ...	1	3.6	1.2
Strawberries, . . .	1	1.4	–
* Strawberries, . . .	1	2.6	–
* Strawberry vines, . . .	1	.7	–
Cherries, ...	1	3.3	–
Plums, ...	1	4.3	–
Saxifragaceæ: —			
* Currants, white, . . .	1	2.8	–
* Currants, red, . . .	1	2.1	–
Gooseberries, . . .	1	1.9	–

3. Relative Proportions of Phosphoric Acid, etc., in Fruits and Garden Crops — *Continued.*

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Viticeæ: —			
Grapes,	1	3.6	1.2
Grape seed,	1	1.0	2.7
Garden Crops.			
Chenopodiaceæ: —			
Mangolds,	1	6.0	2.3
* Mangolds,	1	4.2	2.1
Mangold leaves,	1	4.5	3.0
Sugar beets,	1	4.2	1.8
* Sugar beets,	1	4.8	2.2
Sugar beet tops,	1	2.3	1.7
Sugar beet leaves,	1	5.7	4.3
Sugar beet seed,	1	1.5	–
* Red beets,	1	4.1	3.3
Spinach,	1	1.7	3.1
* Spinach,	1	19.2	6.8
Compositæ: —			
Lettuce, common,	1	5.3	–
Head lettuce,	1	3.9	2.2
* Head lettuce,	1	7.7	4.0
Roman lettuce,	1	2.3	1.8
Artichoke,	1	.63	–
* Artichoke, Jerusalem,	1	2.8	2.7

3. Relative Proportions of Phosphoric Acid, etc., in Fruits and Garden Crops — *Continued.*

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Convolvulaceæ: —			
Sweet potato,	1	4.6	3.0
Cruciferæ: —			
White turnips,	1	3.6	2.3
* White turnips,	1	3.9	1.8
White turnip leaves,	1	3.1	3.3
* Ruta-bagas,	1	4.1	1.6
Savoy cabbage,	1	1.9	2.5
White cabbage,	1	4.1	1.7
* White cabbage,	1	11.0	7.6
Cabbage leaves,	1	4.1	1.7
Cauliflower,	1	2.3	2.5
Horse-radish,	1	3.9	2.2
Radishes,	1	3.2	3.8
Kohlrabi,	1	1.6	1.8
Cucurbitaceæ: —			
Cucumbers,	1	2.0	1.3
Pumpkins,	1	.6	.7
Gramineæ: —			
Corn, whole plant, green,	1	3.7	1.9
* Corn, whole plant, green,	1	2.2	2.8
Corn, kernels,	1	.6	2.8
* Corn, kernels,	1	.6	2.6

3. RELATIVE PROPORTIONS OF PHOSPHORIC ACID, ETC., IN FRUITS AND GARDEN CROPS — *Continued.*

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Gramineæ — *Con.*			
* Corn, whole ears, ...	1	.8	2.5
* Corn, stover, . . .	1	4.4	3.7
Leguminosæ: —			
Hay of peas, cut green, .	1	3.4	3.4
* Cow-pea (*Dolichos*), green, .	1	3.1	2.9
* Small pea (*Lathyrus sylvestris*), dry.	1	3.4	4.2
Peas, seed, ...	1	1.2	4.3
Pea straw, ...	1	2.8	4.0
Garden beans, seed, . .	1	1.2	4.0
Bean straw, ...	1	3.3	–
* Velvet beans, kernel, . .	1	1.7	4.0
* Velvet beans, with pod, .	1	1.56	2.3
* Leaves and stems of velvet beans.	–	–	–
Liliaceæ: —			
* Asparagus, ...	1	3.05	3.06
Asparagus, ...	1	1.3	3.6
Onions, ...	1	1.9	2.1
* Onions, ...	1	2.6	–
Solanaceæ: —			
Potatoes, ...	1	3.6	2.1
* Potatoes, ...	1	4.1	3.0
Potato tops, nearly ripe, .	1	2.7	3.1

3. RELATIVE PROPORTIONS OF PHOSPHORIC ACID, ETC., IN FRUITS AND GARDEN CROPS — *Concluded.*

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Solanaceæ — *Con.*			
Potato tops, unripe, . .	1	3.7	5.3
* Tomatoes, ...	1	8.7	4.5
Tobacco leaves, . . .	1	6.2	5.3
* Tobacco, whole leaf, . .	1	13.46	5.65
Tobacco stalks, . . .	1	3.1	2.7
* Tobacco stems, . . .	1	10.7	3.8
Umbelliferæ : —			
Carrots, ...	1	2.7	2.0
* Carrots, ...	1	5.7	1.7
Carrot tops, ...	1	2.9	5.1
Carrot tops, dry, . . .	1	8.0	5.1
Parsnips, ...	1	3.8	2.8
* Parsnips, ...	1	3.3	1.2
Celery, ...	1	3.5	1.1

4. ANALYSES OF INSECTICIDES.

	Moisture.	Arsenious Oxide.	Copper Oxide.	Lead Oxide.	Zinc Oxide.	Barium Oxide.	Acetic Acid.	Nicotine.	Mercury.	Sulphur.	Sulphuric Acid.	Chlorine.	Calcium Oxide.	Potassium Oxide.	Ferric and Aluminic Oxides.	Insoluble Matter in Hydrochloric Acid.
Average of twenty analyses, Paris green,	.88	59.00	30.89	–	–	–	4.74	–	–	–	–	–	–	–	–	.20
Average of four analyses, "Lion brand, new-process Paris green."	4.64	54.91	7.93	–	–	–	–	–	–	–	6.65	–	15.76	.35	–	1.00
Average of fourteen analyses of Paris green collected in the general markets in 1900–01.	.81	57.73	29.45	–	–	–	–	–	–	–	–	–	–	–	–	–
Pink arsenoid (lead arsenite),	.35	40.16	–	53.83	–	–	–	–	–	–	–	–	–	–	–	–
Green arsenoid (copper arsenite),	1.44	50.77	31.90	–	–	–	–	–	–	–	–	–	–	–	–	–
White arsenoid (barium arsenite),	2.35	31.90	–	.96	–	48.31	–	–	–	–	–	3.19	–	–	–	–
Laurel green,	7.64	7.34	13.50	–	–	–	–	–	–	–	–	–	26.31	–	–	–
Bug death,	.03	–	–	1.58	78.86	–	–	–	–	–	–	–	–	–	3.80	–
Sulphatine,	1.40	–	2.61	–	–	–	–	–	–	48.28	4.73	–	18.60	–	–	1.63
Death to rose bugs,	2.95	–	1.05	–	–	–	–	–	–	34.53	4.35	–	17.76	–	–	.49
Professor De Graff's carpet bug destroyer,	95.81	–	–	–	–	–	–	–	.78	–	.48	.27	–	.26	.90	–
Oriental fertilizer and bug destroyer,	87.14	2.38	–	–	–	–	–	–	–	–	.64	3.00	–	3.50	–	–
Non-poisonous potato bug destroyer,	–	–	–	–	–	–	–	–	–	–	–	–	68.20	–	1.38	1.50
Tobacco liquor,	37.71	–	–	–	–	–	–	2.12	–	–	–	–	3.07	6.55	.23	–
Tobacco liquor,	40.89	–	–	–	–	–	–	.53	–	–	–	–	1.47	16.34	.01	–
Tobacco liquor,	–	–	–	–	–	–	–	4.68	–	–	–	–	–	–	–	–
Nicotina,	10.00	–	–	–	–	–	–	–	–	–	–	–	4.45	9.15	–	2.12
Hellebore,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.34
Hellebore,	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	38.12
Peroxide of silicate,	1.65	.57	.33	–	–	–	–	–	–	–	49.66	–	41.18	–	–	2.31

COMPILATION OF ANALYSES OF FODDER ARTICLES AND DAIRY PRODUCTS, MADE AT AMHERST, MASS., 1868–1905.[1]

E. B. HOLLAND AND P. H. SMITH.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES.
  I. — Green fodders.
    (*a*) Meadow grasses and millets.
    (*b*) Cereal fodders.
    (*c*) Legumes.
    (*d*) Mixed and miscellaneous.
  II. — Silage.
  III. — Hay and dry, coarse fodders.
    (*a*) Meadow grasses and millets.
    (*b*) Cereal fodders.
    (*c*) Legumes.
    (*d*) Straw.
    (*e*) Mixed and miscellaneous.
  IV. — Vegetables, fruits, etc.
  V. — Concentrated feeds.
    (*a*) Protein.
    (*b*) Starchy.
    (*c*) Poultry.
  VI. — Dairy products.
B. FERTILIZER INGREDIENTS OF FODDER ARTICLES. (For classification, see A and C.)
C. ANALYSES OF DAIRY PRODUCTS.

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[1] Part III. of the report of Department of Foods and Feeding.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES.

[Figures equal percentages or pounds in 100.]

	NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.			
			Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
	I. — GREEN FODDERS.											
	(a) Meadow Grasses and Millets.											
	Johnson grass (*Andropogon halepensis*),	1	75	1.4	1.2	8.9	13.2	0.3	-	-	-	-
	Orchard grass (*Dactylis glomerata*),	7	70	2.1	2.9	10.4	13.7	0.9	-	-	-	-
	Tall oat grass (*Arrhenatherum elatius*),	4	70	1.6	2.3	10.8	14.7	0.6	-	-	-	-
Fox-tail millets.	Common millet (*Chætochloa Italica*),	16	80	1.0	1.5	6.5	10.5	0.5	0.9	4.6	7.0	0.3[1]
	Canary bird seed millet (*C. Italica*),	1	80	1.6	1.0	7.1	10.0	0.3	-	-	-	-
	Early harvest millet (*C. Italica*),	1	80	1.4	1.1	7.4	9.7	0.4	-	-	-	-
	Golden millet (*C. Italica*),	1	80	1.2	0.8	7.0	10.7	0.3	-	-	-	-
	Hungarian grass (*C. Italica*),	3	80	1.4	1.9	5.8	10.5	0.4	1.2	4.1	7.0	0.2
	Japanese millet (*C. Italica*),	12	80	1.2	1.7	6.2	10.5	0.4	0.9	3.8	7.0	0.3
Broom-corn millets.	Millet (*Panicum miliaceum*),	1	80	1.1	1.1	5.3	11.7	0.8	-	-	-	-
	Broom-corn millet (*P. miliaceum*),	1	80	1.2	1.3	6.4	10.7	0.4	-	-	-	-
	Hog millet (*P. miliaceum*),	1	80	1.4	1.5	6.5	10.2	0.4	-	-	-	-
	Japanese broom-corn millet (*P. miliaceum*),	2	80	1.2	0.9	6.2	11.4	0.3	-	-	-	-

[1] Same coefficients used as for Hungarian grass.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
I. — GREEN FODDERS — *Con.*											
(a) Meadow Grasses and Millets — Con.											
Barnyard millet (*Panicum crus-galli*),	8	80	1.7	1.9	6.6	9.4	0.4	1.2	4.8	6.7	0.2
Pearl millet (*Pennisetum spicatum*),	1	80	1.4	1.4	6.9	10.1	0.2	–	–	–	–
Japanese millet (variety uncertain),	3	80	1.1	1.2	7.1	10.2	0.4	0.6	4.4	6.8	0.3
(b) Cereal Fodders.											
Barley,	1	75	2.1	3.2	9.4	9.6	0.7	2.3	5.7	6.8	0.4
Barley in milk,	1	75	1.2	2.6	7.3	13.2	0.7	1.8	4.1	9.8	0.3
Corn fodder,	48	80	1.0	1.6	4.7	12.3	0.4	1.0	3.0	9.3	0.3
Sweet corn stover,	2	80	1.2	1.4	4.9	12.0	0.5	0.7	2.8	8.8	0.4[1]
Oats (stage uncertain),	6	75	2.0	3.5	7.5	11.2	0.8	2.6	4.1	6.9	0.6[2]
Oats in bloom,	1	75	1.7	1.6	1.9	12.0	0.7	1.1	5.0	7.4	0.5[2]
Oats in milk,	1	75	1.5	2.7	8.6	11.5	0.7	2.0	4.7	7.1	0.5[2]
Oats, ripe,	1	70	1.9	1.8	10.9	14.6	0.8	–	–	–	–
Rye,	2	75	1.4	1.9	8.0	13.2	0.5	1.5	6.4	9.4	0.4
Winter rye in bloom,	1	75	1.6	2.7	8.3	11.8	0.6	2.1	6.6	8.4	0.4

(c) *Legumes.*											
Alfalfa (*Medicago sativa*),	6	80	1.6	2.7	6.2	9.1	0.4	2.0	2.7	6.6	0.2
Horse bean (*Faba vulgaris*),	1	85	0.9	2.5	4.3	6.9	0.4	-	-	-	-
Soy bean (*Glycine hispida*),	14	80	2.1	3.5	5.4	8.1	0.9	2.7	2.4	6.2	0.5 [3]
Soy bean (early white),	4	80	2.6	3.4	4.5	9.0	0.5	2.7	2.0	6.9.	0.3
Soy bean (medium green),	16	80	2.2	4.1	5.3	7.8	0.6	3.2	2.4	6.0	0.3
Soy bean (medium green), in bud,	1	80	2.5	4.2	5.5	7.3	0.5	3.3	2.8	5.3	0.3
Soy bean (medium green), in blossom,	5	80	2.3	4.0	5.5	7.7	0.5	3.1	2.6	5.5	0.3
Soy bean (medium green), in pod,	9	78	2.3	4.5	5.9	8.6	0.7	3.5	2.7	6.6	0.4
Soy bean (medium black),	2	80	2.5	3.8	4.7	8.0	1.0	3.0	2.1	6.2	0.6
Soy bean (late),	4	80	2.6	4.6	4.2	8.0	0.6	3.6	1.9	6.2	0.3
Clover, alsike (*Trifolium hybridum*),	8	80	2.3	3.3	5.4	8.5	0.5	-	-	-	-
Clover, crimson (*T. incarnatum*),	2	80	2.8	3.1	6.0	7.6	0.5	2.4	3.4	5.6	0.3
Clover, mammoth red (*T. medium*),	4	80	1.9	3.0	5.8	8.9	0.4	-	-	-	-
Clover, medium red (*T. pratense*),	13	80	1.8	3.1	5.7	8.8	0.6	2.0	3.0	6.3	0.4
Clover, medium red, in bud,	2	80	2.1	3.6	4.7	9.0	0.6	2.4	2.5	6.6	0.4 [4]
Clover, medium red, in blossom,	3	79	1.9	3.5	6.0	9.0	0.6	-	-	-	-
Clover, medium red, seeding,	2	75	2.3	3.8	7.2	11.0	0.7	2.4	3.7	7.2	0.4
Sweet clover (*Melilotus alba*),	4	80	1.9	3.8	6.3	7.4	0.6	-	-	-	-
Cow pea (*Vigna catjang*),	12	85	2.0	2.8	3.5	6.3	0.4	2.1	2.1	5.1	0.2 [5]

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[1] Same coefficients used as for corn fodder.

[2] Same coefficients applied to oats in several stages of growth.

[3] Same coefficients applied to all soy beans except to medium green varieties in different stages of growth.

[4] Coefficients taken from the German.

[5] Same coefficients applied to all cow peas.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
I. — GREEN FODDERS — *Con.*											
(*c*) *Legumes* — Con.											
Cow pea, black,	4	85	2.3	3.1	3.4	5.9	0.3	2.4	2.0	4.8	0.2
Cow pea, Whip-poor-will,	5	85	1.9	2.5	3.7	6.6	0.3	1.9	2.2	5.3	0.2
Canada beauty pea (*Pisum arvense*),	1	85	1.2	2.4	4.4	6.6	0.4	–	–	–	–
Canada field pea (*P. arvense*),	8	85	1.3	3.2	4.3	5.8	0.4	–	–	–	–
Canada field pea (*P. arvense*), in bud,	2	85	1.1	3.2	4.1	6.1	0.5	2.6	2.5	4.3	0.3[1]
Canada field pea (*P. arvense*), in blossom,	3	87	1.2	2.8	3.8	4.8	0.4	2.3	1.7	3.6	0.2
Canada field pea (*P. arvense*), in pod,	2	84	1.2	2.3	4.8	6.3	0.4	1.9	2.2	4.8	0.2
English gray pea (*P. arvense*),	1	85	1.4	3.1	4.5	5.5	0.5	–	–	–	–
Prussian blue pea (*P. arvense*),	1	85	1.3	2.8	4.5	5.9	0.5	–	–	–	–
Flat pea (*Lathyrus sylvestris wagneri*),	2	85	1.3	4.4	3.7	5.0	0.6	–	–	–	–
Sainfoin (*Onobrychis sativa*),	1	75	2.1	4.4	6.0	11.6	0.9	–	–	–	–
Serradella (*Ornithopus sativus*),	3	85	1.6	2.2	4.4	6.5	0.3	–	–	–	–
Sulla (*Hedysarum coronarium*),	2	75	2.3	4.3	5.2	12.5	0.7	–	–	–	–
Spring vetch (*Vicia sativa*),	4	85	1.4	2.7	4.5	6.1	0.4	1.9	2.0	4.6	0.2

Winter or sand vetch (*Vicia villosa*),	7	85	2.1	3.4	4.4	4.7	0.4	2.8	2.8	3.6	0.3
Winter or sand vetch (*V. villosa*), in bud,	2	86	2.4	3.3	3.5	4.4	0.4	–	–	–	–
Winter or sand vetch (*V. villosa*), in blossom,	4	82	2.5	4.2	5.5	5.4	0.4	3.5	3.5	4.2	0.3
Kidney vetch (*Anthyllis vulneraria*),	1	85	2.0	2.8	2.3	7.4	0.5	–	–	–	–
(*d*) *Mixed and Miscellaneous.*											
Barley and peas,	1	80	1.6	2.8	6.8	8.2	0.6	2.1	3.5	5.6	0.4
Barley and vetch,	2	80	1.2	2.8	6.5	9.0	0.5	2.1	3.4	6.1	0.3[2]
Corn and soy bean,	3	80	1.5	2.6	5.0	10.4	0.5	–	–	–	–
Corn and cow peas,	1	80	1.8	2.1	5.3	10.4	0.4	–	–	–	–
Sweet corn and cow peas,	1	80	1.5	1.8	4.8	11.4	0.5	–	–	–	–
Millet and peas,	1	80	1.8	2.4	7.5	8.0	0.3	–	–	–	–
Tall oat grass and alsike clover,	2	80	1.5	2.7	5.8	9.5	0.5	–	–	–	–
Orchard grass and alsike clover,	1	80	1.5	2.4	6.5	9.0	0.7	–	–	–	–
Peas and oats,	4	80	1.7	2.9	6.0	8.8	0.6	2.1	3.8	6.3	0.4
Sorghum and cow peas,	1	80	1.6	1.6	6.5	9.9	0.4	–	–	–	–
Vetch and oats (1–1),	3	80	1.8	3.0	6.3	8.4	0.5	2.3	4.3	5.7	0.2
Vetch and oats (1–4),	1	80	1.8	2.7	6.0	8.8	0.7	–	–	–	–
Wheat and vetch,	4	80	1.6	3.4	6.4	8.1	0.5	2.6	4.4	5.9	0.3
Apple pomace,	6	83	0.6	1.0	2.9	11.6	0.9	–	1.9	9.9	0.4
Sugar-beet pulp,	1	90	0.1	1.4	2.5	5.9	0.1	0.9	2.1	5.0	–
Cabbage waste,	1	82	4.9	3.6	2.6	6.6	0.3	–	–	–	–

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[1] Same coefficients applied to Canada field peas in blossom and in pod.

[2] Same coefficients used as for barley and peas.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

NAME.	Number of Analyses.	Composition.						Digestibility.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
I. — GREEN FODDERS — *Con.*											
(*d*) *Mixed and Miscellaneous* — Con.											
Carrot tops,	1	80	2.8	4.2	2.7	9.9	0.4	–	–	–	–
Prickly comfrey (*Symphytum asperrimum*),	1	87	2.8	2.3	1.5	6.1	0.3	–	–	–	–
Purslane (*Portulaca oleracea*),	1	91	1.5	2.3	1.6	3.4	0.2	–	–	–	–
Dwarf Essex rape (*Brassica napus*),	1	85	2.4	1.9	2.9	7.2	0.6	1.7	2.5	6.6	0.3[1]
Summer rape (*B. napus*),	1	85	2.8	2.1	2.7	6.9	0.5	1.9	2.3	6.3	0.2
Winter rape (*B. napus*),	1	85	3.3	2.3	1.8	7.1	0.5	2.0	1.6	6.5	0.2
Sorghum (*Andropogon sorghum*),	7	80	1.3	1.7	5.5	11.1	0.4	–	–	–	–
Spurry (*Spergula arvensis*),	1	72	2.6	2.9	7.0	15.4	0.1	–	–	–	–
Teosinte (*Euchlæna Mexicana*),	2	70	2.3	2.3	9.4	15.6	0.4	–	–	–	–
II. — SILAGE.											
Apple pomace,	1	85	0.6	1.2	3.3	8.8	1.1	–	2.2	7.5	0.5[2]
Corn,	47	80	1.1	1.7	5.4	11.1	0.7	0.8	3.5	7.7	0.5
Corn and soy bean,	6	76	2.3	2.7	7.3	10.9	0.8	1.7	4.5	8.5	0.7
Millet,	3	74	2.4	1.7	7.5	13.6	0.8	–	–	–	–
Millet and soy bean,	9	79	2.8	2.8	7.2	7.2	1.0	1.6	5.0	4.2	0.7

III. — Hay and Dry Coarse Fodders.

(a) Meadow Grasses and Millets.

	Canada blue-grass (*Poa compressa*),	1	14	4.8	5.9	31.3	42.1	0.9	2.5	22.2	26.5	0.3
	Kentucky blue-grass (*Poa pratensis*),	3	14	6.4	7.7	30.5	39.7	1.7	4.4	19.2	21.0	0.7
	Canada hay,	4	14	4.6	6.1	28.1	45.1	2.1	–	–	–	–
	English hay (mixed grasses),	102	14	5.3	7.9	27.7	42.8	2.3	3.7	18.0	25.3	1.0
	Fermented hay,	1	14	6.3	8.4	25.4	43.7	2.2	–	–	–	–
	Meadow fescue (*Festuca elatior pratensis*),	7	14	7.1	5.8	32.2	39.3	1.6	3.0	21.6	23.2	0.9
Millets.	Barnyard grass (*Panicum crus-galli*),	1	14	8.6	13.1	29.0	33.6	1.7	–	–	–	–
	Barnyard millet (*P. crus-galli*),	8	14	7.3	8.2	28.4	40.4	1.7	5.2	17.6	21.0	0.8
	Hungarian grass (*Chætochloa Italica*),	3	14	6.3	8.4	24.6	45.0	1.7	5.0	16.7	30.2	1.1
	Orchard grass (*Dactylis glomerata*),	7	14	5.9	8.3	29.9	39.3	2.6	5.0	18.2	21.6	1.4
	Tall oat grass (*Arrhenatherum elatius*),	4	14	4.6	6.4	30.9	42.1	1.9	3.3	17.0	24.4	1.1
	Red-top (*Agrostis alba vulgaris*),	6	14	4.6	6.5	28.5	44.9	1.5	4.0	17.4	27.8	0.8
	Red-top (*A. alba vulgaris*), early cut,	1	14	4.3	5.8	30.9	43.3	1.7	–	–	–	–
	Red-top (*A. alba vulgaris*), late cut,	1	14	4.1	6.0	31.0	43.2	1.7	–	–	–	–
	Rowen,	29	14	6.4	11.4	23.9	41.3	3.0	7.9	15.8	26.4	1.4
	Italian rye grass (*Lolium Italicum*),	4	14	6.4	7.1	28.6	42.2	1.6	–	–	–	–
	Perennial rye grass (*Lolium perenne*),	4	14	7.9	10.1	25.4	40.5	2.1	–	–	–	–

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[1] Same coefficients applied to all varieties of rape.

[2] Same coefficients used as for fresh apple pomace.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

	NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.			
			Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
	III. — HAY AND DRY COARSE FODDERS — *Con.*											
	(*a*) *Meadow Grasses and Millets* — Con.											
Salt hays.	Black grass (*Juncus Gerardi*),	3	16	7.4	7.0	24.3	43.1	2.2	4.1	14.3	22.4	1.0
	Branch grass (*Distichlis spicata*),	2	16	7.6	6.8	22.4	45.1	2.1	3.8	12.1	22.1	0.7
	Flat sage (*Spartina stricta maritima var?*),	1	16	8.2	6.6	25.0	41.8	2.4	3.4	15.0	23.0	0.9
	Fox grass (*Spartina patens*),	2	16	5.8	6.7	22.5	46.9	2.1	4.0	11.9	24.9	0.8
	High-grown salt hay (largely *Spartina patens*),	1	16	7.0	6.3	22.2	46.4	2.1	3.8	11.8	24.6	0.8
	Cove mixture (black grass and red-top),	1	16	6.0	7.4	23.2	45.6	1.8	3.6	13.9	24.2	0.7
	Mixed salt hay (largely fox grass and branch grass),	1	16	8.4	5.5	22.5	45.5	2.1	2.3	13.1	23.7	0.6
	Salt hay (variety uncertain),	2	16	4.3	3.4	24.0	49.8	2.5	–	–	–	–
	Swamp or swale hay,	2	14	5.8	7.1	26.7	44.5	1.9	2.4	8.8	20.5	0.8
	Timothy (*Phleum pratense*),	8	14	4.2	8.4	28.1	43.4	1.9	4.0	14.1	26.9	1.0
	Timothy (*P. pratense*), early cut,	1	14	4.0	5.7	31.0	43.5	1.8	3.2	17.7	27.4	0.9
	Timothy (*P. pratense*), late cut,	1	14	3.9	5.2	29.7	45.2	2.0	2.2	13.7	26.7	1.0
	White-top (*Agrostis vulgaris var.*),	1	14	6.0	11.2	24.4	41.5	2.9	–	–	–	–

(b) Cereal Fodders.											
Corn stover, from field,	44	40	3.9	4.6	20.6	30.1	0.8	1.7	13.2	17.8	0.5
Corn stover, very dry,	44	20	5.2	6.1	27.4	40.2	1.1	2.2	17.5	23.7	0.7
Oats,	6	15	6.9	11.7	25.5	38.3	2.6	6.2	13.0	21.1	1.6
(c) Legumes.											
Alsike clover,	8	15	9.7	14.0	23.1	36.1	2.1	9.2	11.6	23.8	8.0
Mammoth red clover,	4	15	8.2	13.1	24.4	37.6	1.7	-	-	-	-
Medium red clover,	13	15	7.6	13.2	24.2	37.4	2.6	7.7	13.1	23.9	1.4
(d) Straw.											
Barley,	2	15	4.8	6.5	32.2	39.0	2.5	1.3	18.0	21.1	1.1[1]
Horse bean,	1	15	8.1	8.3	35.2	32.1	1.3	-	-	-	-
Soy bean,	3	15	6.1	4.7	36.1	36.3	1.8	2.4	13.7	24.0	1.1[1]
Millet (*Chætochloa Italica*),	1	15	5.3	3.6	35.2	39.5	1.4	-	-	-	-
Millet (*Panicum crus-galli*),	1	15	4.6	5.2	30.4	42.7	2.1	-	-	-	-
Millet (*P. miliaceum*),	1	15	5.2	3.3	35.9	38.1	2.5	-	-	-	-
Millet (variety uncertain),	1	15	5.8	4.2	35.5	38.3	1.2	-	-	-	-
Wheat,	1	15	4.1	6.2	30.5	42.8	1.4	0.7	15.9	16.3	0.4[1]
(e) Mixed and Miscellaneous.											
Hairy lotus,	2	15	7.0	12.6	16.8	46.1	2.5	-	-	-	-
Oat grass and alsike clover,	2	15	6.5	11.6	24.5	40.1	2.3	-	-	-	-
Orchard grass and alsike clover,	1	15	6.6	10.1	27.6	38.3	2.4	-	-	-	-

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[1] Coefficients taken from the German.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
III. — HAY AND DRY COARSE FODDERS — *Con.*											
(*e*) *Mixed and Miscellaneous* — Con.											
Peas and oats,	4	15	7.2	12.2	25.5	37.5	2.6	8.9	14.8	22.9	1.5
Vetch and oats (1-1),	3	15	7.4	12.8	26.7	35.8	2.3	8.3	13.1	21.1	1.4
Wheat and vetch,	4	15	6.8	14.5	27.2	34.4	2.1	10.7	17.7	23.4	1.3
White daisy,	1	15	6.0	6.6	30.7	39.7	2.0	–	–	–	–
IV. — VEGETABLES, FRUITS, ETC.											
Apples,	2	78	0.7	1.0	1.5	18.3	0.5	–	–	–	–
Artichokes,	1	78	1.1	2.9	0.9	16.9	0.2	–	–	–	–
Beets, red,	7	88	1.1	1.5	0.7	8.6	0.1	–	–	–	–
Sugar beets,	13	86	0.9	1.6	0.9	10.5	0.1	1.5	0.9	10.5	0.1
Yellow fodder beets,	4	89	1.0	1.3	1.0	7.5	0.2	1.0	–	4.2	–
Cabbages,	1	90	0.8	2.6	0.9	5.5	0.2	–	–	–	–
Carrots,	5	89	0.9	1.0	1.1	7.8	0.2	–	–	–	–
Cranberries,	1	89	0.2	0.5	1.2	8.5	0.6	–	–	–	–
Mangolds,	5	88	1.2	1.4	0.8	8.5	0.1	1.0	0.3	7.7	–

Parsnips,	1	80	1.5	1.3	1.5	15.0	0.7	–	–	–	–
Potatoes,	22	80	0.9	2.1	0.5	16.4	0.1	1.0	–	14.8	–
Potatoes,	93	80	–	–	–	14.3[1]	–	–	–	–	–
Ruta-bagas,	3	89	1.1	1.2	1.3	7.2	0.2	1.0	1.0	6.8	0.2
Japanese radish,	1	93	0.7	0.5	0.7	5.0	0.1	–	–	–	–
Turnips,	5	90	0.9	1.5	1.2	6.6	0.2	1.4	1.2	6.3	0.2
V.—CONCENTRATED FEEDS.											
(a) Protein.											
Horse beans,	1	14	3.8	25.8	7.0	48.6	0.8	–	–	–	–
Red adzinki beans,	2	14	3.6	21.0	4.0	56.7	0.7	–	–	–	–
Saddle beans,	1	14	5.3	13.0	4.1	49.4	14.2	–	–	–	–
Soy bean,	5	14	5.0	31.2	4.7	28.4	16.7	–	–	–	–
Soy bean (medium green),	2	14	4.6	35.6	3.9	24.6	17.3	32.4	–	19.9	16.1
Blood meal, Armour's edible,	3	11	3.1	84.3	–	1.2	0.4	70.8	–	–	–
Brewers' dried grains,	9	10	3.4	23.5	12.0	45.6	5.5	19.0	5.9	26.0	4.9
Brewers' wet grains,	1	77	0.7	6.7	3.8	9.8	2.0	5.3	2.0	5.7	1.8
Buckwheat feed,	2	10	3.2	15.9	22.0	44.8	4.1	–	–	–	–
Buckwheat middlings,	3	10	4.7	26.7	6.8	44.6	7.2	22.7	1.1	37.0	6.4
Cocoanut meal,	3	9	4.7	20.4	11.0	40.6	4.3	–	–	–	–
Cotton-seed meal,	319	7	6.6	45.3	6.3	24.6	10.2	38.1	2.2	19.2	9.6
Cotton-seed meal (low grade),	32	8	4.6	24.9	18.0	37.0	7.5	18.2	6.8	25.2	6.8

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[1] Starch.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
V. — CONCENTRATED FEEDS — *Con.*											
(*a*) *Protein* — Con.											
Dairy feed, H-O,	11	8.0	3.3	18.1	12.9	53.5	4.2	13.8	4.5	38.5	3.5
Distillers' dried grains, largely from corn,	56	8.0	1.7	31.7	12.3	34.2	12.1	23.1	11.7	27.7	11.5
Gluten feed,	192	8.5	1.7	26.2	7.2	53.3	3.1	22.3	5.5	47.4	2.6
Gluten flour, wheat,	1	5.5	0.4	84.8	0.2	8.1	1.0	–	–	–	–
Gluten meal, wheat,	2	8.0	0.9	39.8	0.8	48.9	1.6	–	–	–	–
Gluten meal,	138	9.5	1.0	36.0	2.1	49.1	2.3	31.7	–	43.2	2.1
King gluten meal (old process),	6	7.0	1.2	33.3	1.8	43.6	13.1	–	–	–	–
Germ oil meal,	13	9.0	2.7	22.7	9.3	45.9	10.4	15.7	–	37.2	10.1
Flaxseed meal,	2	7.0	3.5	23.5	5.5	23.3	37.2	–	–	–	–
Linseed meal (new process),	52	9.0	5.5	37.5	8.9	36.4	2.7	31.5	6.6	29.1	2.4
Linseed meal (old process),	113	8.5	5.2	34.3	8.6	36.5	6.9	30.5	4.9	28.5	6.1
Malt sprouts,	17	11.0	5.6	26.4	12.6	43.0	1.4	20.1	12.5	36.6	1.2
Bibby's dairy cake,	4	10.0	7.7	19.7	8.6	44.9	9.1	13.0	4.0	36.4	8.4
Blomo feed,	4	20.0	7.6	13.0	14.6	44.2	0.6	8.2	8.9	33.6	0.1

Holstein sugar feed,	1	8.0	6.7	12.6	10.0	60.0	2.7	8.3	4.4	48.6	2.4
Macon sugar feed,	2	6.0	6.6	14.0	10.2	61.6	1.6	8.3	4.5	50.5	1.3
Sucrene dairy feed,	8	10.0	6.3	16.6	11.7	52.1	3.3	10.1	8.4	38.0	3.1
Sucrene oil meal,	3	9.0	5.7	23.2	10.7	48.6	2.8	–	–	–	–
Oat middlings, fine,	4	9.0	2.3	15.8	2.4	64.3	6.2	12.8	1.2	61.7	5.8
Pea meal,	1	10.0	2.6	18.9	17.5	49.4	1.6	15.7	4.6	46.4	0.9
Peanut meal,	1	8.0	4.0	49.0	3.5	24.7	10.8	44.6	0.8	22.7	9.6
Proteina,	4	8.0	2.5	21.8	10.0	51.1	6.6	–	–	–	–
Rye feed,	15	11.0	3.2	14.7	3.8	64.6	2.7	11.8	–	56.8	2.4
Wheat middlings (flour),	106	10.0	3.2	19.2	3.2	59.6	4.8	16.9	1.2	52.4	4.1
Wheat middlings (standard),	308	10.0	4.3	17.9	7.0	55.8	5.0	13.8	2.1	43.5	4.4
Wheat mixed feed, bran and middlings,	732	10.0	5.3	17.0	8.2	55.0	4.5	13.2	5.1	42.4	3.9
Wheat mixed feed, adulterated,	7	10.0	4.3	12.3	15.5	54.6	3.3	7.7	4.3	38.8	3.0
Wheat bran,	379	10.0	6.2	16.3	10.0	53.1	4.4	12.6	3.9	37.7	2.8
Wheat bran (spring),	4	10.0	5.8	16.1	10.5	52.6	5.0	12.2	4.6	38.9	3.2
Wheat bran (winter),	3	10.0	6.2	15.3	8.6	57.0	2.9	11.8	2.3	37.1	1.9
(b) Starchy.											
Bakery refuse,	1	13.0	10.1	8.0	0.3	63.0	5.6	–	–	–	–
Barley,	6	12.0	2.4	11.2	5.7	66.8	1.9	7.8	2.9	61.5	1.7[1]
Broom-corn seed,	2	14.0	2.1	9.6	7.0	63.8	3.5	–	–	–	–
Buckwheat,	1	12.0	1.9	9.9	10.3	63.5	2.4	–	–	–	–

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[1] Digestion coefficients taken from the German.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
V. — CONCENTRATED FEEDS — *Con.*											
(*b*) *Starchy* — Con.											
Cassava starch refuse,	1	12	1.6	0.8	6.1	78.8	0.7	–	–	–	–
Cerealine,	4	11	2.6	11.1	4.9	62.7	7.7	8.9	4.0	59.6	6.2
Cocoa dust,	1	7	6.3	14.4	5.5	42.7	24.1	–	–	–	–
Cocoa shells,	1	5	8.4	18.0	15.9	50.9	1.8	–	–	–	–
Cocoanut meat,	1	1	0.8	9.9	7.5	15.3	65.5	–	–	–	–
Corn bran,	2	11	2.0	10.8	12.4	59.8	4.0	5.8	7.3	46.0	3.1
Corn cobs,	6	8	1.3	2.7	31.3	56.2	0.5	0.5	17.8	27.0	–
Corn and cob meal,	38	11	1.4	8.9	6.7	68.4	3.6	5.0	3.1	60.2	3.0
Corn kernels,	93	11	1.3	10.2	2.0	71.6	3.9	–	–	–	–
Corn meal,	93	14	1.3	9.8	1.9	69.2	3.8	6.3	–	63.7	3.5
Sweet corn kernels,	3	11	1.9	12.5	2.4	64.9	7.3	–	–	–	–
Corn and oat feed,	48	10	3.0	9.1	9.9	64.8	3.2	–	–	–	–
Corn and oat feed (Victor),	39	10	3.5	8.6	11.3	62.9	3.7	6.1	5.4	52.2	3.2
Corn, oat and barley feed,	8	10	3.1	11.4	8.3	62.4	4.8	–	–	–	–

Corn, oat and barley feed (Schumacher's),	14	8	4.0	11.3	11.8	60.3	4.6	-	-	-	-
Corn screenings,	1	11	2.1	7.4	2.9	72.6	4.0	-	-	-	-
Cotton hulls,	5	11	2.6	5.3	39.7	39.0	2.4	-	15.9	16.0	2.1
Cotton-hull bran,	1	11	1.9	2.3	35.0	48.7	1.1	-	-	-	-
Cotton-seed feed,	4	11	3.1	10.5	36.0	35.9	3.5	5.4	16.6	19.8	3.0
Dairy feed (Quaker),	33	8	4.6	13.2	16.8	54.3	3.1	9.2	9.2	32.0	2.3
Flaxseed screenings,	1	7	5.4	15.7	16.5	44.5	10.9	-	-	-	-
Hominy meal,	120	11	2.5	10.4	4.2	64.1	7.8	6.8	2.8	57.0	7.2
Horse feed (H-O),	13	9	3.1	12.6	9.8	62.0	3.5	8.8	5.5	51.5	2.8
Maizeline,	1	5	2.7	10.0	7.9	66.0	8.4	-	-	-	-
Mellen's food refuse,	1	7	3.9	11.4	7.1	67.2	3.4	-	-	-	-
Millet seed,	4	12	2.6	11.1	7.7	62.9	3.7	-	-	-	-
Barnyard millet seed,	1	11	3.3	12.2	7.6	60.3	5.6	-	-	-	-
Molasses, Porto Rico,	2	24	6.8	3.1	-	66.1	-	-	-	-	-
Dried molasses beet pulp,	3	8	5.4	9.5	15.4	61.3	0.4	6.1	12.9	55.8	-
Oat kernels,	9	11	3.0	12.4	8.5	60.4	4.7	10.7	2.6	47.7	3.8[1]
Oats, ground,	9	12	3.0	12.3	8.4	59.7	4.6	10.1	1.2	51.3	3.7[1]
Oat feed,	110	7	5.3	8.0	21.5	55.3	2.9	5.5	7.1	28.2	1.5
Oat feed (low grade),	17	7	5.5	5.1	26.4	54.4	1.6	3.2	8.4	18.0	1.5
Oat feed, Canada,	2	7	5.4	13.2	24.8	44.7	4.9	9.1	8.2	22.8	4.3
Parson's "six-dollar" feed,	1	11	7.9	10.0	17.9	51.1	2.1	5.9	8.4	32.7	1.7

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[1] Coefficients obtained from digestion experiments with horses.

A. COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Concluded.*

NAME.	Number of Analyses.	COMPOSITION.						DIGESTIBILITY.			
		Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
V. — CONCENTRATED FEEDS — *Con.*											
(*b*) *Starchy* — Con.											
Pea bran,	2	11	2.7	10.0	39.7	35.6	1.0	-	-	-	-
Peanut feed, largely husks,	2	10	2.6	8.9	56.4	16.6	5.5	6.3	6.2	8.1	5.0
Peanut husks,	1	13	1.2	5.0	66.0	13.1	1.7	-	-	-	-
Peanut shells,	2	7	2.8	7.1	62.2	19.0	1.9	-	-	-	-
Rice, cleaned,	1	11	0.3	8.5	0.1	79.8	0.3	-	-	-	-
Rice bran,	2	11	12.7	6.8	20.6	42.8	6.1	4.3	6.0	33.4	5.4
Rice meal,	2	11	8.2	11.8	5.3	50.8	12.9	7.3	-	46.7	11.7
Rye middlings,	1	11	3.6	11.7	3.3	65.4	5.0	-	-	-	-
Speltz,	1	8	3.9	11.5	11.1	62.9	2.2	-	-	-	-
Starch refuse,	2	12	1.8	4.8	3.8	76.3	1.3	-	-	-	-
Wheat kernels,	11	11	1.8	12.4	2.7	70.2	1.9	-	-	-	-
Wheat flour,	2	12	0.4	9.9	0.1	76.8	0.8	-	-	-	-

(c) Poultry.											
American poultry food,	14	8	2.9	13.1	6.5	63.6	5.9	–	–	–	–
Cut bone,	1	26	21.5	20.7	–	0.2	31.6	–	–	–	–
Raw ground bone,	1	8	64.4	23.9	–	3.4	0.3	–	–	–	–
Cut clover,	2	10	6.8	17.9	20.5	41.8	3.0	–	–	–	–
H-O poultry food,	3	9	2.7	17.4	4.4	60.2	5.3	–	–	–	–
Meat and bone meal,	37	6	37.4	39.5	–	6.3	10.8	–	–	–	–
Meat scrap,	11	9	17.6	50.8	–	4.5	18.1	–	–	–	–
Mutton scrap,	1	7	33.1	39.9	–	5.3	14.7	–	–	–	–
Granulated milk,	1	10	26.5	35.9	–	18.1	9.6	–	–	–	–

B. FERTILIZER INGREDIENTS OF FODDER ARTICLES.[1]

[Figures equal percentages or pounds in 100.]

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
I. — GREEN FODDERS.					
(a) Meadow Grasses and Millets.					
Orchard grass,	4	70	0.43	0.56	0.13
Millet,	1	80	0.29	0.43	0.11
Barnyard millet,	3	80	0.30	0.67	0.10
Hungarian grass,	1	80	0.30	0.42	0.12
Japanese millet,	3	80	0.33	0.22	0.10
(b) Cereal Fodders.					
Corn fodder,	22	80	0.39	0.30	0.13
Oats,	3	75	0.72	0.56	0.19
Rye,	2	75	0.27	0.57	0.11
(c) Legumes.					
Alfalfa,	4	80	0.44	0.31	0.11
Horse bean,	1	85	0.41	0.21	0.05
Soy bean (early white),	1	80	0.57	0.55	0.13
Soy bean (medium green), average,	14	80	0.64	0.53	0.14
Soy bean (medium green), in bud,	1	80	0.66	0.58	0.15
Soy bean (medium green), in blossom,	5	80	0.64	0.60	0.13
Soy bean (medium green), in pod,	7	78	0.72	0.52	0.17
Soy bean (medium black),	1	80	0.70	0.50	0.16
Soy bean (late),	1	80	0.60	0.68	0.14
Alsike clover,	6	80	0.53	0.50	0.15
Mammoth red clover,	3	80	0.50	0.27[2]	0.12
Medium red clover, average,	10	80	0.52	0.57	0.11
Medium red clover, in bud,	2	80	0.58	0.71	0.13
Medium red clover, in blossom,	3	79	0.51	0.58	0.12
Medium red clover, seeding,	2	75	0.61	0.65	0.13
Sweet clover,	1	80	0.43	0.40	0.12
White lupine,	1	85	0.45	0.26	0.05
Yellow lupine,	1	85	0.40	0.44	0.09

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[1] Many of these analyses were made in earlier years by the Massachusetts State Experiment Station. The percentages of the several ingredients will vary considerably, depending upon the fertility of the soil, and especially upon the stage of growth of the plant. In the majority of cases the number of samples analyzed is too few to give a fair average. The figures, therefore, must be regarded as close approximations, rather than as representing absolutely the exact fertilizing ingredients of the different materials. (J. B. L.)

[2] Evidently below normal.

B. FERTILIZER INGREDIENTS OF FODDER ARTICLES — *Continued.*

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
I. — GREEN FODDERS — *Con.*					
(*c*) *Legumes* — Con.					
Canada field peas, average,	6	85	0.50	0.38	0.12
Canada field peas, in bud,	2	85	0.50	0.44	0.11
Canada field peas, in blossom,	2	87	0.45	0.32	0.11
Canada field peas, in pod,	2	84	0.52	0.37	0.13
Cow pea, average,	9	85	0.45	0.47	0.12
Black cow peas,	4	85	0.40	0.47	0.12
Whip-poor-will cow peas,	5	85	0.49	0.47	0.12
Flat pea,	1	85	0.75	0.32	0.10
Small pea,	1	85	0.40	0.31	0.09
Sainfoin,	1	75	0.68	0.57	0.20
Serradella,	2	85	0.36	0.37	0.12
Sulla,	2	75	0.68	0.58	0.12
Spring vetch,	1	85	0.36	0.45	0.10
Hairy or sand vetch, average,	5	85	0.55	0.51	0.13
Hairy or sand vetch, in bud,	2	86	0.52	0.54	0.12
Hairy or sand vetch, in blossom,	3	82	0.65	0.57	0.16
Kidney vetch,	1	85	0.44	0.28	0.08
Average for legumes,	–	–	0.53	0.44	0.12
(*d*) *Mixed and Miscellaneous.*					
Vetch and oats,	4	80	0.30 [1]	0.30	0.14
Apple pomace,	2	83	0.21	0.12	0.02
Carrot tops,	1	80	0.69	1.08	0.13
Prickly comfrey,	1	87	0.37	0.76	0.12
Common buckwheat,	1	85	0.44	0.54	0.09
Japanese buckwheat,	1	85	0.26	0.53	0.14
Silver-hull buckwheat,	1	85	0.29	0.39	0.14
Summer rape,	1	85	0.34	0.78	0.10
Sorghum,	8	80	0.26	0.29	0.11
Teosinte,	1	70	0.47	1.18	0.06
II. — SILAGE.					
Corn,	7	80	0.42	0.39	0.13
Corn and soy bean,	1	76	0.65	0.36	0.35 [2]
Millet,	3	74	0.26	0.62	0.14
Millet and soy bean,	5	79	0.42	0.44	0.11

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[1] Too low; 0.43 nearer correct.

[2] Evidently too high.

B. FERTILIZER INGREDIENTS OF FODDER ARTICLES — *Continued.*

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
III. — HAY AND DRY COARSE FODDERS.					
(*a*) *Meadow Grasses and Millets.*					
Barnyard millet,	3	14	1.29	2.88	0.43
Hungarian grass,	1	14	1.29	1.79	0.52
Italian rye grass,	4	14	1.12	1.19	0.53
Kentucky blue-grass,	2	14	1.20	1.54	0.39
Meadow fescue,	6	14	0.93	1.98	0.37
Orchard grass,	4	14	1.23	1.60	0.38
Perennial rye grass,	2	14	1.16	1.47	0.53
Red-top,	4	14	1.07	0.95	0.33
Timothy,	3	14	1.20	1.42	0.33
English hay (mixed grasses),	13	14	1.34	1.61	0.32
Rowen,	13	14	1.72	1.58	0.48
Branch grass,	1	16	1.06	0.87	0.19
Fox grass,	1	16	1.18	0.95	0.18
Salt hay (variety uncertain),	1	16	1.05	0.64	0.23
(*b*) *Cereal Fodders.*					
Corn stover, from field,	17	40	0.69	0.92	0.20
Corn stover, very dry,	17	20	0.92	1.22	0.26
Oats,	3	15	2.45[1]	1.90	0.65
(*c*) *Legumes.*					
Alsike clover,	6	15	2.26	2.10	0.63
Mammoth red clover,	3	15	2.14	1.16[2]	0.52
Medium red clover,	10	15	2.21	2.42	0.47
(*d*) *Straw.*					
Barley,	2	15	0.95	2.03	0.19
Soy bean,	1	15	0.69	1.04	0.25
Millet,	1	15	0.68	1.73	0.18
(*e*) *Mixed and Miscellaneous.*					
Vetch and oats,	4	15	1.29[3]	1.27	0.60
Broom corn waste (stalks),	1	10	0.87	1.87	0.47
Palmetto root,	1	12	0.54	1.37	0.16
Spanish moss,	1	15	0.61	0.56	0.07
White daisy,	1	15	0.26	1.18	0.41
IV. — VEGETABLES, FRUITS, ETC.					
Apples,	2	78	0.12	0.17	0.01
Artichokes,	1	78	0.46	0.48	0.17

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[1] Too high; 1.90 nearer correct.

[2] Evidently below normal.

[3] Too low; 1.80 nearer correct.

B. Fertilizer Ingredients of Fodder Articles — *Continued.*

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
IV. — Vegetables, Fruits, etc. — *Con.*					
Beets, red,	8	88.0	0.24	0.44	0.09
Sugar beets,	4	86.0	0.24	0.52	0.11
Yellow fodder beets,	1	89.0	0.23	0.56	0.11
Mangolds,	3	88.0	0.15	0.34	0.14
Carrots,	3	89.0	0.16	0.46	0.09
Cranberries,	1	89.0	0.08	0.10	0 03
Parsnips,	1	80.0	0.22	0.62	0.19
Potatoes,	5	80.0	0.29	0.51	0.08
Japanese radish,	1	93.0	0.08	0.40	0.05
Turnips,	4	90.0	0.17	0.38	0.12
Ruta-bagas,	3	89.0	0.19	0.49	0.12
V. — Concentrated Feeds.					
(*a*) *Protein.*					
Red adzinki bean,	1	14.0	3.27	1.55	0.95
White adzinki bean,	1	14.0	3.45	1.53	1.00
Saddle bean,	1	14.0	2.08	2.09	1.49
Soy bean,	3	14.0	5.61	2.12	1.82
Blood meal (Armour's),	1	11.0	13.55	0.18	0.26
Brewer's dried grains,	2	8.0	3.68	0.86	1.06
Cotton-seed meal,	130	7.0	7.16	2.01	2.86
Distillers' dried grains,	20	8.0	4.50	0.31	0.61
Gluten feed,	72	8.5	4.17	0.37	0.72
Gluten meal,	46	9.5	5.87	0.21	0.55
Linseed meal (new process),	21	9.0	5.97	1.42	1.79
Linseed meal (old process),	43	8.5	5.32	1.29	1.64
Malt sprouts,	12	11.0	4.32	2.00	1.56
Bibby's dairy cake,	1	10.0	2.94	1.67	2.07
Sucrene feed,	1	10.0	2.62	2.08	0.55
Pea meal,	1	10.0	3.04	0.98	1.81
Peanut meal,	1	8.0	7.84	1.54	1.27
Proteina,	1	8.0	3.04	0.58	1.02
Rye feed,	11	11.0	2.36	1.08	1.60
Wheat middlings (flour),	32	10.0	3.16	1.05	1.66
Wheat middlings (standard),	77	10.0	2.92	1.28	2.04
Wheat mixed feed,	223	10.0	2.76	1.43	2.57
Wheat bran,	98	10.0	2.63	1.40	2.82

B. FERTILIZER INGREDIENTS OF FODDER ARTICLES — *Concluded.*

	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
V. — CONCENTRATED FEEDS — *Con.*					
(b) *Starchy.*					
Ground barley,	1	13.0	1.56	0.34	0.66
Buckwheat hulls,	1	12.0	0.49	0.52	0.07
Cocoa dust,	1	7.0	2.30	0.63	1.34
Corn cobs,	8	8.0	0.52	0.63	0.06
Corn and cob meal,	29	11.0	1.38	0.46	0.56
Corn kernels,	13	11.0	1.82	0.40	0.70
Corn meal,	3	14.0	1.92	0.34	0.71
Corn and oat feed (Victor),	2	10.0	1.38	0.61	0.59
Corn, oat and barley feed (Schumachers),	1	8.0	1.80	0.63	0.83
Cotton hulls,	3	11.0	0.75	1.08	0.18
Hominy meal,	49	11.0	1.66	0.78	1.25
Common millet seed,	2	12.0	2.00	0.45	0.95
Japanese millet seed,	1	12.0	1.58	0.35	0.63
Molasses (Porto Rico),	1	24.0	0.51	3.68	0.12
Dried molasses beet pulp,	1	8.0	1.60	1.47	0.16
Oat kernels,	1	11.0	2.05	–	–
Oat feed,	14	7.0	1.26	0.75	0.48
Oat feed (low grade),	15	7.0	0.88	0.70	0.35
Peanut feed,	2	10.0	1.46	0.79	0.23
Peanut husks,	1	13.0	0.80	0.48	0.13
Louisiana rice bran,	1	11.0	1.42	0.83	1.70
Rye middlings,	1	11.0	1.87	0.82	1.28
Damaged wheat,	1	13.0	2.26	0.51	0.83
Wheat flour,	2	12.0	2.02	0.36	0.35
(c) *Poultry.*					
American poultry food,	1	8.0	2.22	0.52	0.98
Meat and bone meal,	10	6.0	5.92	–	14.68
Meat scraps,	4	9.0	7.63	–	8.11
VI. — DAIRY PRODUCTS.					
Whole milk,	297	86.4	0.57	0.19 [1]	0.16 [1]
Human milk,	3	88.1	0.24	–	–
Skim milk,	22	90.3	0.59	0.18 [2]	0.20 [2]
Buttermilk,	1	91.1	0.51	0.05	0.04
Whey,	1	93.7	0.10	0.07	0.17
Butter,	117	12.5	0.19	–	–

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[1] From Farrington and Woll.

[2] From Woll's Handbook.

C. ANALYSES OF DAIRY PRODUCTS.

[Per Cent.]

NAME.	Number of Analyses.	SOLIDS.			FAT.			Proteids (N. × 6.25).	Salt.	Ash.
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.			
Whole milk,	4,103[1]	19.55	10.02	13.63	10.70	1.50	4.43	3.56[2]	–	0.73[3]
Human milk,	3	13.59	10.50	11.87	3.77	1.66	2.52	1.48	–	0.24
Colostrum,	2	24.75	21.25	23.00	3.00	3.00	3.00	2.84[4]	–	1.00
Skim milk (largely from Cooley process),	358	10.48	7.68	9.20	1.80	0.05	0.32	–	–	–
Buttermilk,	31	9.86	6.83	8.33	0.38	0.11	0.27	–	–	–
Cream (from Cooley process),	203	32.78	18.12	26.10	25.00	10.53	17.60	–	–	–
Butter (salted),	149	94.84	82.55	87.28	89.33	75.94	83.04	1.10[5]	3.14	–
Butter (fresh),	14	85.36	72.49	82.24	85.05	72.21	81.48	0.76	–	–
Milk powder (Creamora), one-third skimmed,	1	–	–	93.49	–	–	24.96	23.78	–	6.93
Milk powder (Milcora), skim milk,	1	–	–	90.17	–	–	0.38	30.89	–	8.88

[1] Largely station herd, Jersey blood predominating. [2] Average of 331 samples. [3] Average of 259 samples. [4] Nitrogen. [5] Curd and natural ash.

COEFFICIENTS OF DIGESTIBILITY OF AMERICAN FEED STUFFS. — EXPERIMENTS MADE IN THE UNITED STATES.[1]

J. B. LINDSEY AND P. H. SMITH.

Experiments with Ruminants.
Experiments with Swine.
Experiments with Horses.
Experiments with Poultry.
Experiments with Calves.

Complete through Dec. 31, 1905.

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[1] Being a portion of the report of the Division of Foods and Feeding.

EXPERIMENTS WITH RUMINANTS.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
I. — GREEN FODDERS.									
(a) Meadow Grasses and Millets.									
Grass, meadow, young,	1	1	69	-	-	65	74	72	55
Grass, meadow, young, dried,	1	1	71	-	-	71	77	73	60
Grass, timothy,	1	3	63—65 64	- -	31—33 32	48—48 48	54—58 56	65—67 66	52—54 52
Grass, timothy, rowen,	1	2	- -	65—67 66	- -	72—72 72	60—68 64	67—68 68	51—55 52
Barnyard millet in blossom (Massachusetts),	3	6	67—76 70	- -	45—67 56	58—70 65	71—77 73	65—77 71	54—67 58
Japanese millet, bloom to early seed (Storrs),	2	3	- -	62—66 64	52—58 55	45—57 50	59—63 62	64—68 67	60—72 68
Hungarian grass, early to late bloom,	3	8	61—71 66	61—74 68	- -	59—72 63	65—76 70	64—71 67	48—85 62
(b) Cereal Fodders.									
Barley fodder, bloom,	2	4	- -	62—71 67	- -	69—73 72	49—66 61	69—76 71	56—63 60
Barley fodder, seeds forming,	2	2	- -	66—71 68	40—44 42	67—71 69	47—65 56	- 74	48—50 49
Corn fodder, dent, immature,	5	14	64—74 68	- -	42—43 42	56—80 66	56—76 65	64—79 71	37—83 68

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
I. — GREEN FODDERS — *Con.*									
(*b*) *Cereal Fodders* — Con.									
Corn fodder, dent, milk,	3	9	70	–	–	61	64	76	78
Corn fodder, dent, mature,	9	17	68	72	34	53	57	73	74
Corn fodder, dent, mature, B. & W., coarse,	1	2	51—54 52	– –	– –	20—28 24	46—47 46	57—61 59	74—82 78
Corn fodder, Eureka silage, ears just forming,	1	3	64—69 67	– –	42—43 42	67—68 67	56—61 60	70—74 72	65—67 66
Corn fodder, Sanford, mature,	2	4	63—73 69	67—75 71	14—50 34	46—57 52	67—80 75	67—75 71	53—74 66
Corn fodder, sweet, milk stage,	1	2	77—78 77	– –	– –	77—78 77	74—76 75	80—81 81	73—74 74
Corn fodder, sweet, roasting stage,	9	12	– –	67—79 72	22—61 48	52—69 62	54—72 60	73—82 77	62—82 74
Oat fodder, bloom to early seeding,	3	5	– –	56—65 62	49—68 60	68—76 73	43—63 55	60—67 62	67—72 69
Rye fodder, heading,	1	2	73—74 74	– –	– –	79—80 79	80—80 80	70—71 71	74—74 74
Sorghum fodder, blossom,	1	2	73—73 73	– –	– –	51—56 53	74—75 75	78—78 78	81—82 81

Sorghum fodder, Early Amber, past blossom,	1	2	61—62 61	- -	- -	38—42 40	42—45 42	70—71 71	- 67
Sorghum fodder, average both samples,	2	4	67	-	-	46	59	74	74
(c) *Legumes.*									
Alfalfa fodder,	1	2	61—61 61	- -	40—40 40	73—75 74	42—43 43	71—72 72	38—39 39
Soy beans, variety uncertain, before bloom,	1	2	- -	64—67 66	- -	77—80 79	45—55 50	71—73 72	50—58 54
Soy beans, variety uncertain, seeding,	1	2	- -	61—63 62	- -	68—71 69	38—43 41	72—75 73	49—59 54
Soy beans, medium green, full blossom,	1	2	- -	62—63 63	22—28 25	76—78 77	45—49 47	69—73 71	46—54 50
Soy beans, medium green, seeding,	4	12	62—69 65	65—69 67	16—45 28	74—84 78	31—53 45	71—81 77	31—69 55
Clover, crimson, late blossom,	1	3	- -	68—70 69	- -	77—77 77	54—58 56	74—75 74	63—69 66
Clover, red, late blossom,	1	2	65—67 66	- -	- -	66—68 67	52—53 53	76—79 78	63—66 65
Clover, rowen, late blossom,	1	2	- -	60—62 61	- -	61—62 62	51—54 52	64—68 65	60—61 61
Clover, average two samples,	2	4	65—67 66	60—62 61	- -	61—68 65	51—54 53	64—79 72	60—66 63
Cowpeas, ready for soiling,	2	4	66—77 68	72—76 74	19—28 23	73—77 76	57—62 60	76—84 81	56—62 59
Canada field peas, before bloom,	1	2	68 -	71—72 71	- -	81—83 82	62—62 62	71—71 71	50—55 52
Canada field peas, bloom to seeding,	2	6	60—67 64	- -	26—45 37	79—83 81	40—52 45	72—80 76	45—64 55

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
I. — GREEN FODDERS — *Con.*									
(*c*) *Legumes* — Con.									
Spring vetch (*Vicia sativa*),	1	2	62—62 62	- -	- 17	71—72 71	42—46 44	75—77 76	57—60 59
Winter or hairy vetch (*Vicia villosa*), bloom,	4	14	66—78 71	- -	29—55 42	79—88 83	52—73 63	68—84 77	63—82 71
(*d*) *Mixed and Miscellaneous.*									
Apple pomace,	2	6	66—80 72	- -	24—63 49	- -	36—85 65	80—90 85	39—52 46
Barley and peas, bloom,	3	4	- -	55—71 65	52—55 54	73—81 75	38—61 52	56—76 68	54—65 59
Oats and spring vetch, bloom,	1	3	65—69 67	- -	49—55 53	73—76 75	65—72 68	66—70 68	42—52 47
Oats and peas, bloom,	2	5	69—72 70	67—69 68	45—52 49	68—82 74	54—70 64	66—77 72	51—74 64
Oats and peas, partly seeded,	3	5	- -	58—70 62	36—63 47	68—83 74	48—67 55	56—67 63	55—74 64
Dwarf Essex rape, first growth,	1	2	88—88 88	- -	76—77 76	90—91 90	90—90 90	94—94 94	54—55 54
Dwarf Essex rape, second growth,	1	2	81 -	- -	47—51 49	86—89 87	84—84 84	90—91 90	42—44 43
Dwarf Essex rape, average,	2	4	85	-	63	89	87	92	48
Winter wheat and hairy vetch,	2	5	68—71 69	- -	40—46 44	69—78 75	66—71 68	71—76 73	54—61 57

II. — SILAGE.									
Soy bean silage, goats,	1	2	52—66 59	– –	– –	71—80 76	47—62 55	46—58 52	66—77 72
Soy bean silage, steers,	1	2	50—50 50	– –	– –	54—56 55	42—44 43	61—61 61	47—52 49
Soy bean silage, mammoth yellow, bloom,	1	3	52—65 58	63—73 67	– –	57—69 61	51—67 59	74—80 76	48—60 52
Soy bean silage, average,	3	7	56	67	–	66	53	65	57
Soy bean and barnyard millet silage,	1	4	54—65 59	– –	– –	55—62 57	61—73 69	54—63 59	69—75 72
Soy bean and corn silage (9 beans, 14 corn),	4	8	62—73 69	71—75 72	39—48 42	54—68 63	51—73 62	73—81 78	67—91 83
Clover silage,	2	5	32—52 44	36—54 45	26—51 36	22—40 35	41—55 48	31—56 45	36—60 45
Corn silage, dent, immature, average all trials,	7	17	59—68 64	60—68 64	31—35 33	42—65 53	54—78 68	60—70 66	61—85 71
Corn silage, dent, mature, average all trials,	9	25	57—76 66	60—77 70	24—48 37	21—63 50	45—80 64	63—83 71	65—90 82
Corn silage, dent, Leaming, immature,	2	4	59—66 62	60—68 64	31—35 33	46—51 49	54—71 63	62—66 65	61—77 72
Corn silage, dent, Pride of the North, mature,	1	2	72—76 74	– –	24—28 26	– 45	72—73 73	81—83 82	72—82 77
Corn silage, dent, Virginia, mature,	1	4	57—74 64	60—75 66	– –	21—55 39	51—69 58	66—79 72	65—84 77
Corn silage, Sanford, ears glazing,	1	2	74—76 75	76—77 77	47—48 48	54—54 54	77—78 78	78—80 79	76—78 77
Corn silage, dent, average all trials,	16	46	64	70	37	49	65	69	77
Corn silage, flint, mature, small varieties,	4	11	68—78 75	66—80 77	– –	48—73 65	75—79 77	71—83 79	– 82

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
II. — SILAGE — *Con.*									
Corn silage, flint, large white, partly eared,	1	2	69—70 70	72—73 72	31—37 34	56—56 56	72—72 72	75—76 76	72—74 73
Corn silage, fine crushed, steers,	1	2	60—68 64	- -	- -	32—44 38	72—78 75	60—70 65	75—77 76
Corn silage, fine crushed, sheep,	1	2	51—56 54	- -	- -	21—22 21	59—68 64	53—57 55	67—69 68
Corn silage, mature, fed raw,	1	1	-	-	-	45	59	71	86
Corn silage, mature, cooked,	1	1	-	-	-	39	70	75	87
Corn silage, steamed,	1	2	73—74 73	75—76 76	46—50 48	53—57 55	75—76 76	75—77 76	90—90 90
Corn silage, sweet, mature,	1	2	67—70 68	68—72 70	- -	53—55 54	68—74 71	71—73 72	82—85 83
Kaffir corn silage, well matured,	1	3	54—56 55	56—59 57	- -	22—33 28	57—59 57	59—62 62	47—54 50
Oat and pea silage,	1	2	63—68 65	63—70 67	52—53 52	74—75 75	58—65 61	64—70 67	73—77 75
Cow pea silage,	1	4	59—60 60	- -	- -	57—58 57	50—54 52	72—73 72	62—64 63
Sorghum silage, well matured,	1	3	51—60 57	53—62 59	- -	6—13 9	51—63 58	59—67 64	53—60 56
Silage, mixture of corn, sunflower heads and horse beans.[1]	1	2	64—68 66	66—70 68	40—41 41	60—65 63	56—64 60	71—74 72	75—78 77

Silage, mixture of corn, sunflowers (whole plant) and horse beans.[1]	1	2	64—67 65	68—71 69	20—31 26	57—59 58	63—68 65	72—75 74	72—76 74
III. — HAY AND DRY COARSE FODDERS.									
(*a*) *Meadow Grasses and Millets.*									
Kentucky blue-grass (*Poa pratensis*), bloom,	1	1	56	–	42	57	63	53	43
Canada blue-grass (*Poa compressa*), bloom,	1	2	62—63 62	– –	42—42 42	43—44 43	70—71 71	63—63 63	36—39 37
Blue-joint, bloom,	1	2	67—70 69	68—71 70	– –	68—72 70	71—73 72	66—71 69	51—53 52
Blue-joint, past bloom,	1	1	40	42	–	57	37	43	37
Buffalo grass (*Bulbilis Dactyloides*),	1	1	55	–	6	54	65	62	62
Chess or cheat (*Bromus secalinus*),	1	1	45	–	23	42	46	49	32
Colorado upland hay (largely *Agropyrum tenerum*).	2	6	47—63 56	45—59 52	40—48 43	58—67 62	54—63 59	49—66 57	16—53 34
Crab grass (*Eragrostis Neo Mexicana*), ripe,	3	8	47—57 53	– –	29—52 43	30—56 58	50—66 60	50—59 53	30—52 43
Meadow fescue (*Festuca elatior pratensis*), bloom.	1	2	60—61 61	– –	– 46	51—53 52	– 67	58—60 59	53—54 54
Johnson grass (*Andropogon halepensis*),	2	3	57	–	–	40	68	57	38
Millets.									
Barnyard millet, well headed,	1	3	57—58 57	– –	63—64 63	63—64 64	60—64 62	50—52 52	44—50 46
Barnyard millet, just heading out,	1	2	59—62 61	– –	51—52 52	56—59 58	66—71 69	55—59 57	47—49 48
Cat-tail millet (*Pennisetum spicatum*),	1	2	61—64 62	– –	– –	61—65 63	65—68 67	58—60 59	45—48 46

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[1] Proportion of one acre corn, one-fourth acre sunflower heads and one-half acre horse beans.

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
III. — HAY AND DRY COARSE FODDERS — *Con.*									
(*a*) *Meadow Grasses and Millets* — Con.									
Millets.									
Golden millet,	1	1	54	–	31	23	56	58	49
Hungarian,	1	2	64—66 65	66—67 66	– –	– 60	67—68 68	67—67 67	– 64
Millet (*Chætochloa Italica*),	1	2	52—58 56	– –	16—32 24	30—32 31	60—66 63	52—59 56	48—52 50
Mixed grasses, rich in protein (8-10 per cent.),	15	60	54—65 60	60—66 62	37—53 47	34—65 57	49—70 60	56—67 61	41—58 50
Mixed grasses, timothy predominating,	5	10	49—59 55	51—61 58	16—36 30	37—54 47	46—50 65	56—66 59	34—57 45
Meadow, swale or swamp hay,	1	2	38—40 39	– –	– –	31—37 34	30—36 33	– 46	– 44
Tall oat grass (*Arrhenatherum elatius*), late bloom.	1	2	54—57 55	– –	39—43 41	– 51	53—57 55	56—59 58	54—58 56
Wild oat grass (*Danthonia spicata*),	2	3	60—68 64	61—69 65	– –	49—68 58	65—71 68	62—69 65	36—63 50
Orchard grass, ten days after bloom,	1	1	54	56	–	59	58	54	54
Orchard grass, stage not given,	1	2	57—60 59	– –	– –	60—60 60	60—67 64	55—57 56	55—57 56
Orchard grass, average both samples,	2	3	56	56	–	60	61	55	55
Pasture grass,	1	3	73	73	52	73	76	74	67

	Prairie grass (*Sporobolus Asper*),	1	1	56	–	25	18	61	61	57
	Red-top,	2	3	58—62 60	59—64 61	– –	60—62 61	61—62 61	59—65 62	44—59 51
	Rowen, mixed grasses,	3	12	– –	63—68 65	– –	– 70	62—72 66	60—69 65	44—51 47
	Rowen, chiefly timothy,	1	4	– –	62—67 64	– –	66—69 68	62—73 66	60—65 63	48—51 49
	Rowen, average all trials,	4	16	–	65	–	69	66	64	47
Salt hays.	Black grass (*Juncus Geradi*),	2	5	50—62 56	– –	67—71 69	53—63 58	50—66 59	46—59 52	37—51 44
	Branch grass (*Distichlis spicata*),	2	5	49—57 52	– –	– 58	– 56	48—57 54	45—55 49	27—42 35
	Flat sage (*Spartina stricta maritima var.*),	1	3	55—58 57	– –	61—62 62	50—55 52	60—61 60	54—57 55	33—40 36
	Fox grass (*Spartina patens*),	3	7	51—56 54	– –	57—59 58	56—63 60	46—60 53	51—55 53	17—51 36
	Salt hay mixture, fox and branch grasses, etc.,	1	2	52—56 54	– –	68—70 69	41—43 42	54—61 58	51—54 52	26—30 28
	Timothy, in bloom,	4	8	54—66 59	51—67 58	33—34 34	50—60 57	50—62 57	57—72 63	26—62 48
	Timothy, past bloom,	8	17	47—61 52	43—62 52	30—68 59	32—50 43	32—57 46	53—70 59	23—70 51
	Timothy, stage unknown,	1	4	57—62 59	57—62 59	47—54 50	38—41 40	– –	– –	– –
	Timothy, average all trials,	24	58	55	56	39	48	50	62	50
	Timothy fed with cotton-seed meal (16 hay, 1 meal).	1	2	52—56 54	– –	17—28 22	24—32 28	46—52 49	61—63 62	36—37 36
	Timothy fed with cotton-seed meal (12 hay, 1 meal).	1	2	49—55 52	– –	9—30 20	27—38 32	43—51 47	58—62 60	52—54 53

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
III. — HAY AND DRY COARSE FODDERS — *Con.*									
(*a*) *Meadow Grasses and Millets* — Con.									
Timothy fed with cotton-seed meal (8 hay, 1 meal), .	1	2	44—48 46	– –	3—10 6	18—23 21	40—44 42	53—56 54	42—45 44
Timothy fed with cotton seed meal (4 hay, 1 meal), .	1	2	45—46 46	– –	– –	4—4 4	42—43 43	56—75 57	44—66 55
Timothy fed with cotton-seed meal (2 hay, 1 meal), .	1	2	48—56 52	– –	– 13	– 13	34—44 39	65—71 68	72—74 73
Timothy fed with cotton-seed meal (1 hay, 1 meal), .	1	2	47—52 49	– –	19—23 21	– –	24—26 25	68—78 73	79—87 83
Timothy fed with cotton-seed meal, average all trials,	6	12	50	–	16	20	41	62	57
Timothy and clover, poorly cured, ...	1	2	54—55 55	– –	– –	37—38 38	52—54 53	– 60	– 58
Timothy and red-top, late bloom, ...	1	7	48—60 54	– –	11—24 19	35—43 39	49—63 55	55—66 60	28—51 42
Witch grass (*Triticum repens*), ...	2	4	60—63 61	61—64 62	– –	49—64 58	56—68 62	62—70 66	54—60 57
(*b*) *Cereal Fodders.*									
Barley hay, ...	1	4	59	62	–	65	62	63	41
Corn fodder, dent, immature, average all trials, .	6	15	51—70 62	51—71 63	39—47 43	20—67 50	45—77 67	55—70 62	44—84 65
Corn fodder, dent, immature, B. & W., . . .	1	4	51—64 57	– –	– –	20—36 27	45—74 59	57—66 61	66—84 76

Corn fodder, dent, in milk,	5	11	59—66 63	- -	- -	44—51 50	50—71 64	61—69 66	67—79 75
Corn fodder, dent, mature,	10	30	57—70 66	- -	16—30 23	30—61 45	43—73 63	61—81 73	56—82 70
Corn fodder, flint, ears forming,	1	3	69—72 70	71—73 71	- -	69—73 70	72—73 72	71—73 71	63—71 67
Corn fodder, flint, mature,	5	11	63—73 70	- -	- -	56—79 64	69—80 76	63—78 71	59—79 71
Corn fodder, sweet, mature,	3	6	60—71 67	62—74 70	- -	54—73 64	70—77 74	57—73 68	63—71 74
Corn stover, dent, Pride of the North,	1	2	53—55 54	- -	29—33 31	45—45 45	58—63 61	53—55 54	63—66 65
Corn stover, Eureka silage, ears just forming,	2	4	54—64 59	- -	40—46 43	57—58 53	56—72 65	53—64 59	62—67 65
Corn stover, average all trials,	11	31	53—64 57	49—58 55	29—46 41	11—58 36	52—74 64	53—64 59	49—77 67
Corn stover, below ear,	1	2	64—69 67	- -	- -	15—27 21	71—75 74	65—73 69	79—80 80
Corn stover, above ear,	1	2	52—58 55	- -	- -	17—27 22	69—72 71	50—57 54	62—65 64
Corn stover, minus pith (by hand),	1	3	54—57 55	55—59 57	- -	16—28 20	60—65 63	55—58 57	70—75 72
Corn stover, minus pith, ground (Marsden's process),	1	3	63—64 63	- -	46—55 49	57—62 60	60—61 61	65—66 66	82—83 83
Corn stover, minus pith, ground (Marsden's process), steamed.	1	3	51—59 56	- -	47—55 50	59—60 60	37—54 48	57—62 59	70—85 80
Corn stover, minus pith, average,	3	9	51—64 58	55—59 57	46—55 50	16—62 47	37—65 57	55—66 61	70—85 78
Corn stover, blades and husks,	1	4	60—68 65	- -	15—35 23	41—55 48	67—76 73	64—71 66	53—64 58

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
III. — HAY AND DRY COARSE FODDERS — *Con.*									
(*b*) *Cereal Fodders* — Con.									
Corn stover, tops and blades,	1	2	59—60 60	- -	- -	54—57 55	71—72 71	62—63 62	71—72 71
Corn stover, leaves,	1	2	55—56 56	- -	- -	43—69 56	54—67 61	57—61 59	61—65 63
Corn stover, leaves,	1	2	62—67 65	- -	- -	28—41 35	75—80 78	66—70 68	52—59 56
Corn stover, leaves, average both trials,	2	4	55—67 61	- -	- -	28—69 46	54—80 70	57—70 64	52—65 60
Corn stover, husks,	1	2	71—73 72	- -	- -	24—35 30	78—81 80	- 75	23—42 33
Kaffir corn fodder,	1	4	59—62 61	- -	5—11 8	34—42 38	56—63 60	64—68 66	57—67 61
Kaffir corn stover, shredded,	1	4	54—58 56	- -	13—26 19	29—34 30	65—69 67	56—60 58	77—81 79
Kaffir corn stover,	1	1	63	-	43	50	67	67	60
Kaffir corn stover, average both trials,	2	5	57	-	24	34	67	60	75
Oat hay, bloom to milk,	2	6	51—59 55	50—61 55	35—54 45	47—66 57	54—71 58	47—58 53	44—65 53
Oat hay, milk to dough,	4	14	48—60 54	48—61 54	20—54 37	34—60 52	39—62 48	49—62 56	52—72 64
Oat hay, average all trials,	6	20	54	54	39	53	51	55	60

Oat straw,	1	2	49—52 50	51—53 52	– –	– –	57—58 58	52—55 53	35—41 38
Sorghum fodder, Minnesota Early Amber,	1	3	58—60 58	54—55 54	41—49 44	40—47 43	42—56 49	57—67 61	62—67 65
Sorghum fodder, leaves,	1	2	60—66 63	– –	– –	59—62 61	65—76 70	62—67 65	46—47 47
Sorghum fodder, bagasse,	1	1	61	–	–	14	64	65	46
(c) *Legumes.*									
Alfalfa, first crop, budded to full bloom,	8	17	56—72 63	– –	34—67 58	61—84 71	31—65 49	68—76 72	23—61 41
Alfalfa, second crop, budded to full bloom,	6	12	58—67 62	– –	38—59 51	64—81 75	41—49 45	70—79 73	34—48 42
Alfalfa, third crop,	1	2	56—60 58	– –	40—49 44	68—70 69	28—40 34	71—71 71	38—45 42
Alfalfa, average three crops,	15	31	62	–	54	72	47	72	41
Alfalfa, average all trials,	21	39	62	–	53	72	47	72	43
Soy bean,	1	2	62—63 62	– –	– –	70—72 71	59—62 61	66—71 69	19—40 29
Clover, alsike, full to late bloom,	4	9	55—64 59	56—65 60	– 42	64—71 66	40—59 50	59—74 66	21—69 38
Clover, crimson,	3	9	57—65 62	52—58 56	– –	64—73 69	32—58 45	52—74 62	29—54 44
Clover, red,	7	18	49—67 57	51—66 54	0—41 30	47—69 58	42—70 54	56—72 64	40—70 55
Clover, white,	1	1	66	67	–	73	61	70	51
Clover, rowen,	2	4	– –	58—60 59	42—50 46	60—69 65	45—51 47	62—64 63	58—60 60

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
III. — HAY AND DRY COARSE FODDERS — *Con.*									
(*c*) *Legumes* — Con.									
Cow pea,	1	2	- 59	- -	- -	64—65 65	41—45 43	- 71	46—54 50
Peanut vine,	1	2	59—60 60	- -	- -	63—64 63	51—53 52	69—70 70	62—70 66
Spring vetch (*Vicia sativa*),	1	2	65—67 66	66—68 67	52—53 53	69—71 70	54—61 58	71—72 72	70—72 71
Winter or hairy vetch (*Vicia villosa*),	1	6	68—71 69	- -	34—46 42	81—83 82	60—63 61	71—75 73	69—74 70
(*d*) *Mixed and Miscellaneous.*									
Buttercups (*Ranunculus acris*),	1	2	56	57	-	56	41	67	70
Cotton-seed feed (4 to 1),[1] sheep,	2	6	54—60 56	- -	23—35 28	36—45 41	51—60 56	57—60 59	86—94 91
Cotton-seed feed (5 to 1), steers,	1	3	42—45 43	- -	20—24 22	32—41 36	28—33 31	50—59 54	83—86 84
Cotton-seed feed (7 to 1) and (6 to 1), steers,	1	3	45—46 46	- -	- 28	44—46 45	34—40 37	50—51 50	81—82 82
Cotton-seed feed (4 to 1), steers,	1	2	54	-	46	54	45	58	85
Cotton-seed feed (3 to 1) to (2 to 1), steers,	2	9	54	-	32	64	47	54	85
Cotton-seed feed, average both (4 to 1) trials,	3	8	56	-	33	44	53	59	90

Cotton-seed feed, average all trials,	7	23	52	-	30	51	46	55	86
Cotton-seed hulls,	4	13	35—47 41	- -	- -	0—25 6	0.5—58 47	13—46 34	58—89 79
Oats and peas,	2	7	56—67 61	56—67 60	54—65 58	69—78 73	50—64 58	54—66 61	51—69 59
Oats and sand vetch,	1	2	55—55 55	56—56 56	43—46 44	64—66 65	48—50 49	58—59 59	58—67 63
Oats and spring vetch,	2	5	57—63 59	- 60	- 60	60—71 65	47—67 57	34—65 59	17—76 52
Oats and vetch, average,	3	7	58	58	56	65	55	59	55
Salt bush (*Atriplex Argentea*),	1	3	46—47 46	31—32 31	71—72 72	65—68 66	3—15 8	46—51 49	50—55 52
Wheat and sand vetch,	2	6	64—69 66	- -	33—60 47	70—77 74	63—66 65	67—71 68	62—67 64
White weed (*Leucanthemum vulgare*),	1	2	58	58	-	58	46	67	62
IV. — ROOTS AND TUBERS.									
Sugar beets,	1	2	94—95 95	98—100 99	- -	90—93 91	88—113 100	100—100 100	40—53 50
Mangolds,	1	2	77—80 79	83—87 85	- -	70—80 75	27—59 43	91—92 91	- -
Potatoes,	1	3	73—80 77	75—81 78	- -	43—45 44	- -	87—93 91	- 13
Ruta-bagas,	1	2	84—90 87	89—93 91	- -	75—86 80	61—87 74	94—95 95	77—92 84
English flat turnips,	1	2	91—95 93	93—99 96	- -	84—95 90	89—117 100	96—97 97	82—92 88

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[1] Four hulls to one meal.

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
V. — CONCENTRATED FEED STUFFS.									
(a) Protein.									
Soy bean meal, variety unknown,	2	3	75—79 78	- -	- -	89—91 90	0—73 33	68—73 71	81—98 89
Soy bean meal, medium green, coarse ground,	2	4	81—98 90	- -	42—77 57	88—95 91	- -	61—100 81	89—97 93
Bibby's dairy cake,	2	6	61—81 70	- -	18—44 33	58—76 66	1—68 46	71—88 81	84—99 92
Blood meal, Armour's,	1	2	- -	- -	- -	80—88 84	- -	- -	- -
Brewers' dried grains,	2	5	56—62 62	- -	- -	78—84 81	28—62 49	51—60 57	87—93 89
Buckwheat middlings,	1	3	71—79 75	- -	26—41 36	83—86 85	8—26 17	79—87 83	87—92 89
Cotton-seed, raw,	1	2	63—69 66	- -	- -	66—70 68	65—86 76	49—50 50	- 87
Cotton-seed, roasted,	1	2	53—58 56	- -	- -	44—50 47	62—69 66	50—53 51	68—75 72
Cotton-seed meal,	4	12	67—90 79	81—95 88	- 84	76—96 84	26—55 35	66—96 78	87—100 94
Cotton-seed meal, high grade (Maine),	1	2	90	95	-	83	-	96	100
Cotton-seed meal, medium grade (Maine),	1	2	67—79 73	73—83 78	- -	81—86 84	40—47 44	73—91 82	95—95 95

Cotton-seed meal, low grade (Maine),	1	2	60—63 62	62—67 65	– –	72—73 73	30—45 38	66—70 68	87—93 90
Cotton-seed meal, high grade, dark colored, slightly fermented (Maine).	1	2	81—91 86	85—95 90	– –	82—83 83	– –	90—100 95	95—100 98
Dairy feed, H-O,	2	4	65—65 65	– –	– –	68—80 76	14—43 35	67—75 72	83—88 84
Distillers' dried grains, brand R, largely from rye,	1	2	56—59 58	– –	– –	56—63 59	– ?	61—73 67	80—88 84
Distillers' dried grains, largely from corn,	8	17	70—89 79	– –	– –	66—80 73	59—100+ 95	69—97 81	88—98 95
Germ oil meal,	2	5	72—83 76	– 75	– –	65—77 73	– –	68—82 76	95—98 96
Gluten feed,	7	13	85—91 86	92—93 93	– –	85—86 85	– 76	89—90 89	– 83
Gluten meal,	4	8	75—95 87	– –	– –	86—93 88	– –	78—94 88	91—99 93
Linseed meal, old process,	1	3	75—82 79	– –	– –	86—93 89	38—71 57	76—79 78	85—92 89
Linseed meal, new process,	1	3	73—83 78	– –	– –	82—88 85	49—100 74	82—87 84	90—98 93
Linseed meal, new process, Cleveland flax,	3	9	76—88 83	– 79	– –	– 83	– –	– 79	– 87
Linseed meal, new process, average,	4	12	82	79	–	84	74	80	89
Malt sprouts,	1	1	67	68	–	80	34	69	100
Malt sprouts (Mass.),	1	3	75—89 82	– –	3—33 19	74—77 76	98—100 99	76—91 85	74—100 87
Maize feed (Chicago),	1	2	83—85 84	– –	– –	83—84 84	68—76 72	84—87 85	90—90 90

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
V. — CONCENTRATED FEED STUFFS — *Con.*									
(*a*) *Protein* — Con.									
Oat middlings, fine,	1	2	88—91 90	– –	31—40 36	80—81 81	21—77 49	94—97 96	93—94 94
Pea meal,	1	2	85—88 87	86—89 88	– –	80—86 83	25—26 26	93—94 94	52—57 55
Cow pea meal,	1	2	85—88 87	– –	22—45 33	80—85 82	62—66 64	92—94 93	74—74 74
Rye feed, bran and middlings,	1	3	77—83 82	– –	25—48 35	78—82 80	– –	86—89 88	79—99 90
Wheat bran, spring,	3	7	62—70 67	69—74 71	20—32 25	74—82 76	22—76 44	70—80 74	38—83 63
Wheat bran, winter,	1	3	57—66 62	– –	– –	75—79 77	– 27	62—76 65	51—80 64
Wheat bran, average all trials,	4	10	66	–	–	77	39	71	63
Wheat feed flour,	1	2	67—67 67	70—70 70	– –	78—80 79	– –	73—78 76	– –
Wheat middlings, flour,	2	4	78—86 82	81—84 83	– –	82—91 88	33—40 36	84—91 88	82—88 86
Wheat middlings, standard,	2	6	–	73	25	77	30	78	88
Wheat mixed feed, bran and middlings,	2	4	71—78 73	73—81 76	34—43 37	77—79 78	47—79 62	74—79 77	81—92 87
Wheat mixed feed, adulterated with corn cobs,	1	3	59—65 62	61—67 64	28—34 31	62—63 63	17—36 28	68—74 71	91—93 92

(*b*) *Starchy.*									
Cerealine feed,	1	3	89—92 90	- -	- -	79—81 80	72—92 82	93—97 95	78—83 81
Chop feed, corn bran and germs,	2	6	71—92 80	- -	- -	56—77 67	54—70 62	64—92 84	61—86 82
Corn bran,	2	4	70—71 70	- -	- -	53—55 54	50—65 59	74—80 77	69—85 77
Corn cobs,	1	2	59—60 59	- -	- -	13—22 17	65—66 65	60—60 60	44—56 50
Corn meal, coarse,	2	4	74—93 84	75—94 86	- -	45—54 48	- -	79—91 86	- -
Corn meal, fine,	2	3	87—89 88	89—90 90	- -	48—63 54	- -	87—95 91	- -
Corn meal, average all trials,	9	21	74—98 88	75—94 90	- -	40—87 66	- -	79—100 92	71—99 91
Corn and cob meal,	1	3	74—83 79	- -	- -	43—65 52	2—86 45	86—91 88	82—85 84
Corn and oat feed, Victor,	1	3	74—76 75	- -	- -	66—75 71	36—58 48	81—85 83	84—88 87
Kaffir corn kernels,	2	6	29—58 43	- -	- -	28—54 41	- -	34—62 45	- -
Kaffir corn meal,	2	5	54—76 66	- -	- -	36—62 53	- -	67—84 77	25—62 46
White Kaffir heads,	1	4	14—35 24	- -	24—83 54	7—23 12	0—46 27	14—40 31	5—65 31
Dairy feed, Quaker,	3	8	58—64 62	- 52	- -	62—72 70	54—56 55	55—71 59	72—80 74
Hominy meal,	3	8	71—91 82	- -	11—60 37	54—74 65	2—100+ 67	82—94 89	88—95 92

EXPERIMENTS WITH RUMINANTS — *Concluded.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
V. — CONCENTRATED FEED STUFFS — *Con.*									
(*b*) *Starchy* — Con.									
Horse feed, H-O,	3	5	70—77 74	– 78	– –	62—81 70	52—59 56	79—85 83	74—87 80
Molasses Feeds.									
Alma dried molasses beet pulp,	1	2	82—87 85	– –	55—69 62	59—69 64	83—84 84	89—93 91	– –
Blomo feed,	1	2	64—69 67	– –	31—32 32	61—64 63	51—72 61	73—79 76	14—17 16
Holstein sugar feed,	1	3	70—74 71	– –	24—43 33	61—71 66	26—62 44	79—82 81	86—89 88
Macon sugar feed,	1	2	69—72 71	– –	20—21 20	57—61 59	36—51 44	81—83 82	74—91 82
Sucrene dairy feed,	1	2	67—72 69	– –	28—47 38	57—64 61	70—73 72	71—75 73	93—96 95
Molasses feeds, average last three,	3	7	70	–	36	63	52	80	88
Oats, unground,	2	6	66—74 70	68—74 71	2—61 25	72—81 77	15—40 31	74—79 77	87—92 89
Oat feed, Royal,	1	3	42—51 47	42—53 48	33—40 37	64—72 69	20—43 33	50—54 51	86—92 88
Oat feed, excessive hulls,	1	3	29—38 34	– –	8—21 13	51—69 62	25—37 32	29—36 33	89—97 92
Oat feed, average last two,	2	6	40	–	25	65	32	42	90
Parson's "Six-dollar" feed,	1	2	55—56 56	– –	10—14 12	56—62 59	45—50 47	63—65 64	80—81 81

Peanut feed, largely husks,	1	2	32—32 32	– –	– –	70—71 71	10—13 12	41—58 49	90—90 90
Rice meal,	1	2	71—76 74	– –	– –	– 62	– ?	89—95 92	91—92 91
Rice bran,	2	4	56—66 62	– –	1—34 18	58—68 64	13—42 21	76—81 78	52—92 72
Rye meal,	1	2	85—90 87	– –	– –	83—85 84	– –	89—94 92	63—65 64
Rice polish,	1	2	82—83 83	– –	27—36 31	65—66 66	22—23 22	92—93 93	66—81 74

Experiments with Swine.

Barley meal,	1	1	80	80	–	81	49	87	57
Linseed meal, old process,	1	4	76—79 77	– –	8—12 10	83—90 86	10—14 12	82—87 85	78—82 80
Maize kernels,	1	1	83	83	–	69	38	89	46
Maize meal,	2	2	89—90 90	91—92 92	– –	86—90 88	29—49 39	94—94 94	78—82 80
Maize meal with cobs,	1	1	76	77	–	76	29	84	82
Hog millet seed (*Panicum miliaceum*),	1	1	73	–	19	68	33	92	59
Pea meal,	1	1	90	92	–	89	78	95	50
Potatoes,	1	4	97	–	–	84	–	98	–
Wheat, whole,	1	?	72	–	–	70	30	74	60
Wheat, cracked,	1	?	82	–	–	80	60	83	70
Wheat shorts (middlings),	1	2	74—79 77	– –	– –	71—75 73	25—48 37	85—88 87	– –
Wheat bran,	1	2	54—78 66	– –	– –	74—76 75	30—39 34	56—75 66	65—78 72

EXPERIMENTS WITH HORSES.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
Corn kernels,	1	2	71—78 74	– –	20—32 26	40—76 58	– –	85—92 88	43—52 48
Corn meal, same as above,	1	2	84—93 88	– –	– –	74—77 76	– –	93—99 96	70—76 73
Corn stover minus pith, ground (Marsden's process),	1	2	40—59 50	– –	6—37 22	65—70 68	38—71 55	39—54 47	48—72 60
Oat kernels,	1	2	67—77 72	– –	31—36 33	84—87 86	13—49 31	75—83 79	80—85 82
Oats, ground, same as above,	1	2	73—78 76	– –	9—49 29	81—83 82	0.6—28 14	85—87 86	79—81 80
Oats, average of both,	2	4	74	–	31	84	22	82	81
Timothy hay,	1	2	39—48 44	– –	29—39 34	18—24 21	37—48 43	44—50 47	44—51 47

EXPERIMENTS WITH POULTRY.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fibre (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
Corn kernels,	1	3	– –	– 86	– –	44—58 50	– –	90—96 92	88—95 92
Corn kernels,	1	5	– –	86—87 87	– –	80—87 84	1—25 15	88—91 89	81—87 85
Corn meal,	1	3	– –	– 85	– –	41—55 48	– –	91—92 91	92—94 93
Kaffir corn kernels,	1	3	– –	– 88	– –	50—55 53	17—22 20	94—98 96	71—73 74

Kaffir corn meal,	1	3	– –	– 87	– –	42—44 43	30—42 35	95—97 96	82—84 83
Meat,	1	2	– –	87—87 87	– –	90—91 91	– –	– –	86—87 87
Oats,	1	8	– –	60—68 64	– –	68—81 74	4—11 8	65—75 71	77—85 81
Cow peas,	1	3	– –	– 71	– –	32—48 40	2—43 18	86—88 87	87—90 89
Cow pea meal,	1	3	– –	– 72	– –	40—49 44	8—11 10	84—91 88	75—98 89
Wheat,	1	1	–	84	–	77	–	89	59

EXPERIMENTS WITH CALVES.

Whole milk,	2	8	– –	– –	– –	90—98 95	– –	– –	93—99 97
Pasteurized whole milk,	2	9	– –	– –	– –	88—95 93	– –	– –	91—99 95
Cooked whole milk,	1	3	– –	– –	– –	80—94 87	– –	– –	92—99 95
Raw skim milk,	1	3	– –	– –	– –	94—95 95	– –	– –	– –
Skim milk, with sheep,	1	3	96—102 97	– 100	46—74 62	93—96 94	– –	– 100	– 100

Literature. — The following publications have been consulted in compiling the foregoing tables of digestibility: —

Colorado Experiment Station, Bulletins 8, 93.

Connecticut (Storrs) Experiment Station, reports for 1894–96, 1898.

Illinois Experiment Station, Bulletins 43, 58.

Kansas Experiment Station, Bulletin 103.

Louisiana Experiment Station, Bulletin 77, second series.

Maine Experiment Station, reports for 1886–91, 1893, 1894, 1897, 1898, 1900; Bulletin 110.

Maryland Experiment Station, Bulletins 20, 41, 43, 51, 77, 86.

Massachusetts, Hatch Experiment Station, reports for 1895–99, 1901–05; Bulletin 50 and unpublished data.

Massachusetts, State Experiment Station, reports for 1893, 1894.

Minnesota Experiment Station, reports for 1894–96; Bulletins 26, 36, 42, 47, 80.

Mississippi Experiment Station, report for 1895.

New York Experiment Station, reports for 1884, 1888, 1889; Bulletin 141.

North Carolina Experiment Station, Bulletins 80*c*, 81, 87*d*, 97, 118, 148, 160, 172.

Oklahoma Experiment Station, Bulletins 37, 46.

Oregon Experiment Station, Bulletins 6, 47, 85.

Pennsylvania Experiment Station, reports for 1887–94, 1897, 1898, 1900–01, 1903–04.

Tennessee Experiment Station, unpublished data.

Texas Experiment Station, Bulletins 13, 15, 19.

Utah Experiment Station, Bulletins 16, 54, 58.

United States Department of Agriculture, Bureau of Animal Industry, Bulletin 56.

Wisconsin Experiment Station, report for 1889; Bulletin 3.

Wyoming Experiment Station, unpublished data.

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OF THE

MASSACHUSETTS

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MASSACHUSETTS
AGRICULTURAL EXPERIMENT STATION
OF THE
MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, MASS.

ORGANIZATION.

Committee on Experiment Department.

CHARLES H. PRESTON, *Chairman*
J. LEWIS ELLSWORTH.
WILLIAM H. BOWKER.
JAMES DRAPER.
SAMUEL C. DAMON.
THE PRESIDENT OF THE COLLEGE, *ex officio*.
THE DIRECTOR OF THE STATION, *ex officio*.

Station Staff.

CHARLES A. GOESSMANN, Ph.D., LL.D.,	*Honorary Director and Chemist* (fertilizers).
WILLIAM P. BROOKS, Ph.D.,	*Director and Agriculturist.*
GEORGE E. STONE, Ph.D.,	*Botanist.*
JOSEPH B. LINDSEY, Ph.D.,	*Chemist* (foods and feeding).
CHARLES H. FERNALD, Ph.D.,	*Entomologist.*
FRANK A. WAUGH, M.S.,	*Horticulturist.*
J. E. OSTRANDER, C.E.,	*Meteorologist.*
HENRY T. FERNALD, Ph.D.,	*Associate Entomologist.*
JAMES B. PAIGE, D.V.S.,	*Veterinarian.*
ERWIN S. FULTON, B.Sc.,	*Assistant Agriculturist.*
NEIL F. MONAHAN, B Sc.,	*Assistant Botanist.*
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EDWARD G. PROULX, B.Sc.,	*Second Assistant Chemist* (fertilizers).
E. THORNDIKE LADD, B.Sc.,	*Third Assistant Chemist* (fertilizers).
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CHARLES P. HALLIGAN, B.Sc.,	*Assistant Horticulturist.*
EDWIN F. GASKILL, B.Sc.,	*Assistant Agriculturist.*
T. A. BARRY,	*Observer.*

REPORT OF THE DIRECTOR.

During the past year the work of the station has for the most part followed the usual lines, but an important change in policy, as affecting college and station, should be noted. Early last year it was voted by the Board of Trustees to separate the administrative duties of the presidency of the college and the directorship of the station, and a director was elected. The station, it will be remembered, is a department of the college, and the director, therefore, is responsible to the president. He is made *ex officio* a member of the committee of the Board of Trustees on the experiment department, without vote. Although this change, as stated, was voted early last year, it did not become practically operative until early in July, for up to that time the director-elect served as acting president of the college as well as director, so that his time and energies were divided.

The Adams Act.

The past year has been rendered notable in station history by the passage of the Adams act, granting additional appropriations to all the agricultural experiment stations of the country. This act takes its name from the late Hon. H. C. Adams of Wisconsin, who labored long and earnestly to secure its passage, and who perhaps in a very real sense gave his life for the passage of the bill which bears his name.

The Adams bill provided an appropriation by the national government of $5,000 to each experiment station for the year ended June 30, 1906. It provides for an increase of $2,000 in the amount appropriated for each station annually until the total amount per year for each State reaches $15,000, at which figure it is then to remain. This act will then, in brief, within a few years double the amount of the national appropriations to each of the experiment stations of the country. This act was approved on March 16, 1906. There was for a time doubt as to whether the first installment of $5,000 would become available during the fiscal year ended June 30 last. A final decision was not made until very late in June. The passage of the act had, however, been anticipated, and, in preparation for an increase in the scope of station work, the principal part of the first installment was used in the purchase of scientific apparatus. The Adams bill stipulates that the funds which it makes available are "to be applied only to all the necessary expenses of conducting original researches or experiments bearing directly on the agricultural industry of the United States." It should by the terms of the bill be devoted to research of the highest scientific character. No part of the funds made available by the Adams bill can be used for ordinary administrative expenses or for publication.

The bill was so drawn that acceptance of its provisions by the Legislatures of the several States was a necessary prerequisite to the reception of the funds which it provided. Such acceptance on the part of the Legislature of Massachusetts was promptly obtained.

Change in the Name of the Station.

At the time when work was organized under the Hatch act, establishing experiment stations as departments of agricultural colleges, there was already in existence in Amherst a station organized under State law, known as the Massachusetts Experiment Station. It will be remembered that for some years the two stations continued in operation side by side and without disadvantage, for there was agreement as to the lines of investigation to be undertaken by each, and there was no duplication of work. The fact that the name Massachusetts Experiment Station was already in use made it necessary to adopt another name; and, as a mark of respect to Senator Hatch, to whose activity and influence the establishment of the stations under the general government had been due, this experiment department in Massachusetts was called the Hatch Experiment Station. In the course of a few years it became apparent that superior economy in the administrative work of the Massachusetts stations might be secured should both come under one organization. An act of the Legislature was secured, uniting the State station with the Hatch station, and under the latter name. The use of this name has been attended with numerous minor disadvantages. The reason for its adoption is not generally understood. It is contrary to the custom in other States to give the stations a special name; in all other States the station is known by the name of the State. It has therefore seemed best to conform to this general practice, and the name of this station by act of the Legislature recently secured has been changed to the Massachusetts Agricultural Experiment Station.

Changes in Staff.

No very important changes in the general policy of the station have been made during the year, and yet it has been a year of progress. The station has been fortunate in retaining the services of all the heads of its various divisions, and in June last the scope of its work was extended through the establishment of a division of veterinary science, of which Dr. James B. Paige was made the head.

A considerable number of minor changes in the station staff have been made necessary, owing to the fact that assistants in various departments have left us to take positions of greater responsibility and emolument. These changes have been as follows: —

E. S. Fulton, B.S., in place of F. R. Church, B.S.

E. F. Gaskill, B.S., appointed assistant agriculturist, in place of S. B. Haskell, B.S.

Howard S. Parsons, dairy tester, in place of Sumner R. Parker, B.S.

Charles P. Halligan, B.S., assistant horticulturist, in place of Walter B. Hatch, B.S.

Lewell S. Walker, B.S., assistant chemist, in place of Arthur C. Whittier, B.S.

W. K. Hepburn, inspector, in place of Frank G. Helyar, B.S.

T. A. Barry, observer, in place of C. H. Chadwick.

The correspondence, as pointed out by the heads of a number of divisions, has largely increased. This increase has affected not simply the heads of divisions, but the director's office as well, and has made necessary the employment of an increased number of private secretaries. The clerical work of the station now affords full employment for from five to six such assistants.

New Lines of Work.

During the past year two new lines of work have been undertaken, in both instances at the solicitation and with the hearty co-operation of persons engaged in the special industries affected.

Asparagus growing is an important industry in a number of sections. Of late years it has been found difficult to produce satisfactory crops, on account of the prevalence of rust. It is hoped that it may be possible to obtain or to produce more rust-resistant varieties of this crop; and, for the purpose of working with that end in view, an arrangement has been made with the division of plant industry of the department of agriculture for co-operative work. Much of this work will be carried on in Concord, which is the center of what is without doubt the most important asparagus-producing section in the State. In connection with the asparagus-breeding experiments in Concord, an extended series of fertilizer experiments is also to be undertaken. Considerable preliminary work in both directions has been done during the past year.

The cranberry industry, which is so important chiefly in the seaboard towns of southeastern Massachusetts, has long suffered from a variety of insect pests. An important beginning has been made in the study of these pests during the past season. In this work the station has employed an assistant, who spent the entire summer in Wareham, which is one of the principal towns of the cranberry district of Plymouth County. The results of his work and important suggestions as to methods of fighting the injury due to some of the more serious insect pests will be presented in a bulletin, which will be ready for publication at an early date.

An extended series of experiments in the use of fertilizers for cranberries has also been begun during the past year. The bogs where these experiments are in progress under direct station management are located in Falmouth. An almost equally extensive series of experiments with fertilizers has been begun on the bogs of one of the largest private growers.

Revision of Mailing Lists.

The mailing lists of the station have been kept by the card catalogue system, and have not been revised for a number of years. These lists include a total of some 25,000 cards. It is believed that they may include duplicates, and a considerable number of names of parties who no longer care for our publications, — possibly of persons deceased or removed. An important beginning has been made in the revising of these lists. The revision now in progress will be made of the most thorough possible character, and as soon as it can be completed, improved systems of addressing and mailing will be installed.

Work under the Adams Act.

Careful plans have been laid for investigations under the Adams act. These investigations, as will be evident from the statement made concerning the nature of the work which can be undertaken under it, will usually extend over a considerable number of years. A portion of the work with asparagus and cranberries, which has been referred to, will be provided for out of the funds furnished by this act.

Among other lines of work which have been begun are investigations to determine the effect of feed on the composition of milk and butter fat and on the consistency or body of butter; the effect of Porto Rico molasses on the digestibility of hay, and of hay and a nitrogenous concentrate; the preparation of descriptions and life histories of important groups of insects; and a study of the relations of climate to the development of plants and crops both in health and disease.

BULLETINS ISSUED.

Meteorological bulletins have been issued monthly, as usual, and in addition the station has published and distributed four other bulletins, — two on fertilizers, one on the inspection of concentrates and one on market milk.

The fertilizer bulletins, Nos. 109 and 111, have presented the analyses of the fertilizers officially examined under the fertilizer law, as well as the analyses of a considerable number of soils and the more abundant miscellaneous materials possessing fertilizer value, which are sent in by the general public. They have also included brief discussions of the results.

The bulletin on the inspection of concentrates, No. 108, besides presenting the results of the analyses of food stuffs collected under the feed law, included much valuable information on the general subject of food stuffs and their use.

The bulletin on market milk, No. 110, included: first, general discussion of the composition and value of milk as food; second, it presented the results of an examination into the conditions under which the milk marketed in parts of Northampton and Amherst is produced, as well as the results of a critical examination of samples of this milk. The milk was subjected to physical, chemical and bacteriological tests, for the purpose of determining its quality, value and suitability as human food. The results are carefully and fully discussed, and some of the more important conclusions presented were as follows: Very little milk showed evidence of adulteration, and most of it was sweet. The larger part of it was above the average in chemical composition. Bacteria were especially numerous in the product of cows kept under uncleanly conditions, and such samples were far too numerous. Many samples showed barny or disagreeable smell, apparently due to the fact that the milk was allowed to stand too long in the stable after milking. The general conclusion was, that a great deal of the milk offered for general consumption was not produced under satisfactory sanitary conditions. The bulletin concludes with brief, important and pointed practical suggestions both to producers and to consumers.

Besides the bulletins which have been mentioned, three others have been prepared, and are now in press: No. 112, "The Examination of Cattle and Poultry Feeds;" No. 113, "Fertilizer Bulletin;" and No. 114, "The Oriental Moth: a Recent Importation."

BULLETINS AND REPORTS AVAILABLE FOR FREE DISTRIBUTION.

The supply of many of the reports and bulletins which have been issued by the station, available for general distribution, has been exhausted, but those in the following list will still be furnished on application: —

No. 3.	Tuberculosis.
No. 33.	Glossary of fodder terms.
No. 34.	Fertilizer analyses.
No. 41.	On the use of tuberculin (translated from Dr. Bang).
No. 64.	Analyses of concentrated feed stuffs.
No. 68.	Fertilizer analyses.
No. 76.	The imported elm-leaf beetle.
No. 81.	Fertilizer analyses; treatment of barnyard manure with absorbents; trade values of fertilizing ingredients.
No. 83.	Fertilizer analyses.
No. 84.	Fertilizer analyses.
No. 89.	Fertilizer analyses; ash analyses of plants; instructions regarding sampling of materials to be forwarded for analysis.
No. 90.	Fertilizer analyses.
No. 92.	Fertilizer analyses.
No. 96.	Fungicides; insecticides; spraying calendar.
No. 97.	A farm wood lot.
No. 99.	Dried molasses beet pulp; the nutrition of horses.
No. 100.	Fertilizer analyses; market values of fertilizing ingredients.
No. 102.	Analyses of manurial substances and fertilizers; market values of fertilizing ingredients.
No. 103.	Analyses of manurial substances; instructions regarding sampling of materials to be forwarded for analysis; instructions to manufacturers, importers, agents and sellers of commercial fertilizers; discussion of trade values of fertilizing ingredients.
No. 105.	Tomatoes under glass; methods of pruning tomatoes.

No. 107. Analyses of manurial substances forwarded for examination; market values of fertilizing ingredients; analyses of licensed fertilizers collected in the general markets.
No. 109. Analyses of manurial substances forwarded for examination; analyses of Paris green and other insecticides found in the general markets; instructions regarding the sampling of materials to be forwarded for analysis; instructions to manufacturers, importers, agents and sellers of commercial fertilizers; discussion of trade values of fertilizing ingredients for 1906.
No. 110. Market milk.
No. 112. The examination of cattle and poultry feeds.
No. 113. Fertilizer analyses.
No. 114. The oriental moth: a recent importation.

Of most of the other bulletins of the station a few copies still remain; these will be supplied only to complete sets for libraries.

The co-operation and assistance of farmers, fruit growers and horticulturists, and all interested directly or indirectly in agriculture, is earnestly requested. Communications may be addressed to the "Massachusetts Agricultural Experiment Station, Amherst, Mass."

REPORTS OF DIVISIONS.

The reports of the different heads of divisions are transmitted herewith.

The report of the meteorologist calls attention to two or three important improvements in equipment.

The report of the agriculturist is elsewhere briefly summarized.

The report of the fertilizer section of the division of chemistry calls attention to a moderate increase in the number of fertilizers licensed in the State and in the number analyzed. Three hundred and fifty-four brands of fertilizers and chemicals have been licensed in Massachusetts during the year. As was pointed out in the last annual report, there can be no possible necessity for such a large number of different kinds of fertilizers. The report of the chemist this year emphasizes this point. It should be more generally understood that the fertilizers purchased by the farmer cost more as a consequence of this needless multiplication of brands. It would seem to be the part of common sense for the manufacturers to reduce their number, for whatever enables them to lower the price to the consumer must eventually help manufacturer and dealer as well as consumer. The fertilizers analyzed during the past year have shown an improvement in quality, as compared with stated composition. No particular improvement can be noted in the direction of better adaptation to crops. The different brands of special crop fertilizers show the same extreme variations as heretofore. It is evident that not all of the fertilizers advertised as suitable for any particular crop can possibly meet the promises of the manufacturers. The analyses completed by the station show some decline in the general quality of wood ashes, and the report emphasizes the desirability that consumers of ashes should purchase only on a guarantee as to quality.

The report of the section of foods and feeding is largely devoted to the presentation of the results of experiments to determine the digestibility of some of the newer food stuffs. The publication of such results seems to be essential as a basis for proper use of such materials. The report calls attention to the general results of the analyses of samples of drinking water, which indicate, as in previous years, the necessity of caution in cases where contamination seems possible or is suspected. The report includes also brief statements of the results of the execution of the feed and dairy laws. Dealers in food stuffs seem in general disposed to comply with the law, although in a few cases it is believed that retailers are in the habit of removing or failing to attach labels required by the law. Attention is called to the fact that the tests of Babcock glassware for accuracy show a comparatively large proportion to be inaccurately graduated. There is much need of greater care on the part of manufacturers.

The results of a feeding trial in which Porto Rico molasses was tested are presented. They show such molasses to have apparently about 80 per cent. of the value of corn meal. Attention, however, is called to the fact that molasses depresses the digestibility of other foods. Should it be found that such depression inevitably follows the use of molasses, this consideration will materially decrease its value as a food stuff.

Feeding experiments with alfalfa meal indicate that it is not equal to wheat bran in food value, as is claimed by some of its manufacturers.

Experiments with sorghum as a fodder show that the large quantities of seed sometimes recommended are unnecessary, and that the fodder fills a useful place in a soiling system.

The report of the botanist and vegetable pathologist covers a considerable variety of topics. Attention is called to the tonic influence of Bordeaux mixture on plant assimilation. As a result of this influence, it seems apparent that the benefit following the application of Bordeaux mixture is not due solely to the prevention of disease, but in considerable measure as well to increased vigor of growth.

Attention is called to the importance of further study for the discovery of a remedy for tomato rot, which so seriously injures the greenhouse crop in this State.

The report shows a considerable increase in the amount of work done by the station in testing seeds for farmers and gardeners. It presents a review of the year as regards the prevalence of plant diseases. It seems that during the past year the potato has been comparatively free from disease, while celery, pears and apples have been affected to an unusual degree. The report calls attention to defoliation of fruit trees not infrequently following improper spraying, and makes important suggestions in connection therewith.

Attention is called to a bacterial disease of cucumbers under glass. It has been found that relatively late planting insures absolute or comparative freedom from this disease. A bacterial disease of lettuce is common in the south, and growers are cautioned to be on the outlook for similar disease in their houses. The promptest measures should be taken to eradicate it, should it appear.

Attention is called to a serious trouble which tobacco growers have experienced within the last year or two, which appears to be due to improper use of fertilizers.

It is pointed out that the lime and sulfur treatment now so often adopted as a means of destroying the San José scale exercises a repressive influence upon a number of fungous diseases. It has been noted that fruit trees have been remarkably free from such diseases, and the fruit unusually perfect and free from imperfections where the lime and sulfur treatment has been practiced, and the opinion is expressed that the San José scale may prove " a blessing in disguise."

A brief report is presented of the trial of a number of different fungicides for potatoes. The wet Bordeaux mixture was found to be superior to any of the dry applications, but the results of the season are comparatively inconclusive.

The report includes an important paper upon banding substances which are used for the protection of trees and shrubs from insects. Relatively few of the substances upon the market satisfy all the requirements in such a material. A number of them prove highly injurious if applied direct to the bark.

The report of the botanist includes a paper on the injury to trees caused by illuminating gas. It appears that a large amount of careless work has been done in the putting in of gas mains. The injury to trees consequent upon the escape of illuminating gas into the soil surrounding their roots has in a number of instances proved very serious.

The report concludes with a discussion as to the varying texture of soil required for some of our more important special crops.

The report of the entomologists calls attention to the large amount of injury to various greenhouse crops consequent upon the attacks of the white fly. Fumigation with hydrocyanic acid gas has been found the most successful method of destroying this insect, but the results of such fumigation have in numerous instances resulted in great injury to the plants fumigated. The capacity of different plants to endure such fumigation is for the most part unknown. This subject has been carefully investigated for greenhouse tomatoes, and a bulletin soon to be published will present the results and give definite directions. The report calls attention to the rapid spread of the San José scale, which seems to be at present distributed in nearly every town east of the Connecticut River. The scale is found in old as well as in recently set trees. The report calls attention to the fact that earlier experiments here showed the lime and sulfur treatment to be the most effective. Later investigation confirms these early results. The report deals briefly with a number of the proprietary mixtures recommended for the destruction of the San José scale, but states that none of them has been found equal to the lime and sulfur mixture. The report makes mention of the work on cranberry insects and the investigation as to the newly imported oriental moth, both of which have been previously referred to. It concludes with brief reference to some of the more destructive insects of the year.

The report of the veterinarian briefly discusses the nature of the work which his department has been called upon to do. It will be remembered that this division has been organized only since July.

The report of the horticulturist makes brief mention of the different lines of experimental work in progress, and reports in detail the results of experiments in mushroom growing. These indicate pure-culture spawn to be much superior to the ordinary commercial spawn, and that there is a wide difference in the characteristics of different varieties as regards productiveness and quality. The results indicate that the possibilities of profit in mushroom culture are by no means as great as is often represented.

WILLIAM P. BROOKS,
Director.

ANNUAL REPORT

Of George F. Mills, *Treasurer* of the Massachusetts Agricultural Experiment Station of the Massachusetts Agricultural College,

For the Year ending June 30, 1906.

Cash received from United States Treasurer, . . .		$14,617 70
Unexpended balance, 1904–05, ...		382 30
		$15,000 00
Cash paid for salaries, ...	$6,539 52	
for labor, ...	3,003 07	
for publications, ...	719 01	
for postage and stationery, . .	438 09	
for freight and express, . .	168 01	
for heat, light, water and power, .	245 42	
for chemical supplies, . . .	406 54	
for seeds, plants and sundry supplies, ...	525 57	
for fertilizers, ...	569 43	
for feeding stuffs, ...	699 10	
for library, ...	21 10	
for tools, implements and machinery, ...	246 05	
for furniture and fixtures, . .	51 52	
for scientific apparatus, . . .	292 62	
for live stock, ...	195 25	
for travelling expenses, . .	229 66	
for contingent expenses, . .	25 00	
for building and repairs, . .	625 04	
		$15,000 00
Cash received from State Treasurer, . .	$13,500 00	
from fertilizer fees, . .	4,745 00	
from farm products, . .	2,836 02	
from miscellaneous sources, .	4,993 76	
		$26,074 78

Cash paid for salaries,	$13,411 67	
for labor,	2,220 35	
for publications,	809 52	
for postage and stationery,	394 61	
for freight and express,	186 63	
for heat, light, water and power,	1,118 36	
for chemical supplies,	237 79	
for seeds, plants and sundry supplies,	680 65	
for fertilizers,	67 55	
for feeding stuffs,	902 65	
for library,	142 60	
for tools, implements and machinery,	58 10	
for furniture and fixtures,	212 13	
for scientific apparatus,	1,210 72	
for live stock,	10 00	
for travelling expenses,	1,587 59	
for contingent expenses,	88 10	
for buildings and repairs,	170 47	
Balance,	2,495 29	
		$26,074 78

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

The work of the meteorological division during the past year has been continued along the same lines as in previous years. While changes in the instruments at times are necessary, and a modification in the form of the records must occasionally be made, these are avoided unless the necessity is very apparent. The value of a set of records at any station is dependent on the uniformity with which they have been made, as well as on the length of time covered. Notwithstanding the objections to a change, it was considered advisable at the beginning of the year to discontinue the publication of the wind movement as given by the Draper anemometer, and to use instead that given by the electric register which was installed last year. This was done so that our records would be better comparable with those of the United States Weather Bureau meteorological stations, which use electric recorders. A comparison of the two records at this station shows a difference of from 5 to 10 per cent. in the total movement during a month, that of the electric register usually being the larger. The Draper records are still taken, and will be continued during the coming year for the purpose of further comparison.

The records of the electric sunshine recorder have been substituted for those of the Draper instrument, and, while they are made more precise, it is not thought that the monthly results are materially affected by the change.

With the close of the year the records for eighteen years will be complete. A summary of the records for the first ten years was published in the report for 1900. This summary has been carried along to date for the purpose of deducing mean values which are taken for the normals of the station. It should again be published when the records for twenty years are completed.

The usual monthly bulletins have been issued, and the one for December will contain a summary of the records for the year. The station has also furnished the Boston office of the United States Weather Bureau with the monthly voluntary observers' reports, and has arranged to send weekly snow reports during the winter season.

The local forecasts are received by telegraph daily, Sundays excepted, from the Boston office, and the proper flags are displayed.

During the year a new Draper self-recording thermometer was purchased, to replace the one in use. A new maximum thermometer of standard pattern was purchased, to replace the one in use which was broken in resetting. A Felt and Tarrent comptometer has been added to the equipment, and is used in making many of the computations. All computations are checked, to reduce the probability of errors to a minimum.

In February Mr. C. H. Chadwick, the observer, retired to accept a position in civil engineering in the south; and the assistant observer, Mr. T. A. Barry, was advanced to the place.

REPORT OF THE AGRICULTURIST.

WM. P. BROOKS; ASSISTANTS, E. S. FULTON, E. F. GASKILL.

The work carried on in the agricultural division of the experiment station during the past season has involved the care of 308 field plots in the various fertilizer and variety tests; 150 closed plots, largely used in fertilizer experiments; and 286 pots in vegetation experiments, mainly designed to throw light upon problems connected with the use of fertilizers. It will be remembered that a large number of the experiments in this division are continued from year to year. Such repetitions are desirable, for reasons which are fully set forth in the last annual report. A detailed account of results obtained will at this time be presented only for a relatively small number of the experiments in progress. The experiments discussed, and the more important results, briefly stated, are as follows: —

I. — Experiment to determine the relative value as sources of nitrogen of barnyard manure, nitrate of soda, sulfate of ammonia and dried blood. This experiment has been in progress since 1890. The crop of this year was corn, and on the basis of yield the nitrogen materials under comparison rank in the following order: barnyard manure, nitrate of soda, sulfate of ammonia, dried blood. On the basis of increase in crop, as compared with the product of the no-nitrogen plots, taking into account all the crops grown since the experiment began (1890), the materials on a percentage basis rank as follows: nitrate of soda, 100; barnyard manure, 85.31; dried blood, 70.06; sulfate of ammonia, 63.54.

II. — Experiment to determine the relative value of muriate and high-grade sulfate of potash. The crops on the basis of which comparisons are possible this year were soy beans, asparagus, rhubarb, raspberries, blackberries, mixed hay and potatoes. The sulfate of potash gives the larger crops in the case of soy beans, rhubarb, raspberries, blackberries, potatoes, and (as the average of two experiments) for mixed hay. The muriate gives the larger crop of asparagus.

III. — Experiment to determine the relative value of different potash salts for field crops. The salts under comparison were kainit, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and silicate. The crop was potatoes. The salts on the average of five trials for each rank as follows: muriate, low-grade sulfate, high-grade sulfate, nitrate, carbonate, kainit and silicate. Where potash is not used as a fertilizer, the vines appear to be far more susceptible to early blight than on the other plots.

IV. — Experiment to show the relative value in corn and hay production of special corn fertilizers, as compared with a fertilizer mixture richer in potash. The crop of the past season was mixed grass and clover. The special corn fertilizer gave the larger yield at the first cutting, the fertilizer richer in potash the larger yield of rowen. This experiment has continued since 1891. Ten corn crops and six crops each of hay and rowen have been produced. As the average of the entire number of experiments, the special corn fertilizer has given a slightly larger yield of grain and less stover than the mixture of materials richer in potash. As the average of six years' results, the mixture richer in potash has given the larger crops both of hay and rowen.

V. — Experiment to determine the relative value for production of corn and mixed hay of manure alone, as compared with a smaller application of manure and a moderate amount of sulfate of potash. The crop of the past year was mixed hay. The larger application of manure alone gave slightly larger yields both at the first and second cuttings than the combination of the smaller amount of manure and potash. This experiment has continued sixteen years. Ten corn crops and six crops each of hay and rowen have been harvested. The average yields both of corn and hay have been greater on the larger amount of manure alone, but not sufficiently greater, estimating the manure to cost $5 per cord, to cover the larger cost of the manure applied to those plots where it is used alone.

VI. — Experiment to determine the relative value, as measured by crop production, of a considerable number of phosphates used in quantities to furnish equal phosphoric acid to each plot. The phosphates under comparison are fine ground, — apatite, South Carolina rock and Tennessee rock phosphates; Florida soft phosphate, basic slag meal, dissolved bone black, raw bone meal, dissolved bone meal, steamed bone meal and acid phosphate. The crop of the past season was mixed hay. The yields on the different phosphates varied relatively little, indicating that the hay crop is dependent in far less degree upon the quantity of available phosphoric acid applied than are the crops belonging to the Cruciferæ, such as cabbages and turnips, as shown by previous trials.

VII. — Soil tests. The past season was the eighteenth during which the soil test reported in detail has continued. The results show the great importance of a supply of nitrogen in highly available form for the production of a satisfactory hay crop.

VIII. — Experiment in applying manurial substances in rotation for the production of grass. The materials applied in the rotation are: first, barnyard manure; second, wood ashes; and third, a combination of fine-ground bone and potash. The average yield of hay during the past season was at the rate of 4,002 pounds per acre. The average for the fourteen years during which the experiment has continued has been 6,389 pounds.

IX. — An experiment comparing winter with spring application of manure on a slope. The crop of the past year was corn, and the results indicate a small loss in fertilizer value, resulting from winter application, but the gain in crop where the manure was applied in spring was not sufficient to repay the extra cost in handling the manure in that manner.

X. — Experiment in the application of nitrate of soda for rowen. The increase in crop during the past season was considerably more than sufficient to cover the cost of the application; but the results in the different years that the experiment has continued show a wide variation with the amount of rainfall during the season of growth of the crop.

XI. — A variety test of potatoes, including twenty-five varieties. The most productive varieties, mentioned in order, were: Climax, Chenango White, Hammond's Wonderful and Simmon's Model, all of which gave a yield in excess of 200 bushels merchantable potatoes per acre.

XII. — Comparisons of food combinations furnishing the essential nutrients in varying proportions for laying hens. The results indicate corn to have superior merit among the different grains for the production of eggs whenever the total fiber content of the ration is low, and the fat content relatively high. Rice, which contains less fiber than any other grain, gives a satisfactory egg product, but costs too much to render its use advisable.

I. — Manures and Fertilizers furnishing Nitrogen compared. (Field A.)

The materials furnishing nitrogen which are under comparison in this experiment are barnyard manure, nitrate of soda, sulfate of ammonia and dried blood. With few and unimportant exceptions, each plot has been manured in the same way since 1890. The field includes eleven plots, of one-tenth acre each. All the plots annually receive equal and liberal amounts of phosphoric acid and potash. The phosphoric acid is supplied to all plots in the form of dissolved bone black. The potash is applied to six plots (1, 3, 6, 7, 8 and 9) in the form of muriate; it is applied to four plots (2, 4, 5, and 10) in the form of low-grade sulfate. There are three plots in the field which have had no nitrogen applied to them in any form since 1884. The nitrogen materials under comparison are applied in such quantities as to furnish nitrogen at the rate of 45 pounds per acre to each. Barnyard manure is used on one plot, nitrate of soda on two, sulfate of ammonia on three and dried blood on two.

The plots to which nitrogen has been applied in the form of sulfate of ammonia have shown a tendency to comparative unproductiveness, due without doubt to unfavorable chemical or biological conditions. These unfavorable conditions have apparently tended to prevent or to retard the nitrification of the ammonia nitrogen. As a means of correcting the faulty conditions, 50 pounds of unslaked lime were applied to plot

6 in 1896. Twice since that date, in 1898 and in 1905, the entire field has been limed, as observation of the growth of the crops, especially of clover, indicated that liming would be beneficial. In 1898, lime was applied at the rate of 2,000 pounds per acre of air-slaked lime. In 1905, 2,395 pounds of slaked lime were applied to the entire field, this being at the rate of a little more than a ton to the acre.

The crops grown in this experiment previous to this year in the order of their succession have been: oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover, potatoes, soy beans, potatoes, soy beans, potatoes, oats and peas.

The crop of the past season was Rustler White Dent corn, the seed having been obtained in Minnesota. It may be here remarked that this variety seems to be well adapted to our local soil and climatic conditions. It gave a thoroughly matured crop and a heavy yield.

After the harvest of the crop of the season 1905 (oats and peas), the land was replowed and sown to clover late in August. This clover made a poor start, and was badly injured by the winter. The condition in the spring was best on plot 0 (manure). It was poorest on plots 5 and 6 (sulfate of ammonia). On these there were but few living plants remaining. The condition of the clover being so poor, the field was plowed on May 18. The manure and the fertilizers were applied in accordance with the regular system on May 21. The field was harrowed thoroughly on May 22 and 23; it was planted on the 23d. The crop was thoroughly cared for, and no exceptional conditions likely to interfere with the experiment were noted. The rates of yield on the several plots and the sources of nitrogen on each are shown in the following table: —

Yield of Corn and Stover per Acre.

Plots.	NITROGEN FERTILIZERS USED.	CORN (BUSHELS). First Quality.	CORN (BUSHELS). Second Quality.	Stover (Pounds).
0, . .	Barnyard manure, ...	86.71	16.14	6,500
1, . .	Nitrate of soda (muriate of potash), . .	62.14	13.57	6,300
2, . .	Nitrate of soda (sulfate of potash), . . .	70.00	14.00	6,100
3, . .	Dried blood (muriate of potash), . . .	62.43	10.43	6,000
4, . .	No nitrogen (sulfate of potash), . . .	34.29	13.86	6,200
5, . .	Sulfate of ammonia (sulfate of potash), . .	62.57	10.00	5,400
6, . .	Sulfate of ammonia (muriate of potash), .	62.86	9.86	5,350
7, . .	No nitrogen (muriate of potash), . . .	35.00	10.00	5,350
8, . .	Sulfate of ammonia (muriate of potash), .	61.71	12.86	5,930
9, . .	No nitrogen (muriate of potash), . . .	29.29	15.71	5,600
10, . .	Dried blood (sulfate of potash), . . .	57.71	12.57	5,800

The yield on the three no-nitrogen plots (4, 7 and 9) is much inferior to that on any of the others, although it is still almost equal to the average rate of yield of corn per acre in this State. The yield on all the plots receiving nitrogen was good, but wide differences will be noticed. The plot to which manure was applied gave a yield much superior to that obtained on any of the other plots. The relative rank of the manure plot with most of the crops grown has been much lower. In corn, as is well understood, we have a crop capable, in unusual degree, of utilizing the nitrogen of our coarser manures, since its principal growth occurs at a season sufficiently late so that the nitrogen of the comparatively inert organic compounds of the manure can previously have been rendered available by the natural processes of decay and nitrification, for which the warm weather of the early and mid-summer months is so favorable.

The average yields of this year on the several fertilizers are shown in the following table: —

FERTILIZERS USED.	CORN (BUSHELS).		Stover (Pounds).
	First Quality.	Second Quality.	
Average of no-nitrogen plots (4, 7, 9),	32.86	13.19	5,717
Average of the nitrate of soda plots (1, 2),	66.07	13.79	6,200
Average of the dried blood plots (3, 10),	60.07	11.50	5,900
Average of the sulfate of ammonia plots (5, 6, 8),	62.38	10.90	5,560

As a result of all the experiments previous to this year, it has been found that the materials furnishing nitrogen have produced crops in the following relative amounts: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	94.47
Dried blood,	91.09
Sulfate of ammonia,	88.83
No nitrogen,	71.52

Similar averages for this year are as follows: —

	Per Cent.	
	Corn.	Stover.
Nitrate of soda,	100.00	100.00
Barnyard manure,	131.24	104.83
Sulfate of ammonia,	94.41	89.68
Dried blood,	90.92	95.16
No nitrogen,	49.73	92.20

If we combine the results showing relative standing in 1906 with the similar figures for all the years previous to 1906, the relative standing is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	96.63
Dried blood,	91.08
Sulfate of ammonia,	89.14
No nitrogen,	70.24

All the figures showing relative standing included in the above tables are based upon the total yields. Presented in this way, they are not without interest. Of even greater interest, however, will be a comparison on the basis of the increases as compared with the no-nitrogen plots, due to the different nitrogen-containing materials which have been used. On this basis, increase in crop, rather than on the basis of total product, the manure and fertilizers used as a source of nitrogen rank to date for the entire period of the experiment, 1890 to 1906, inclusive, as follows: —

Relative Increases in Yields (Averages for the Seventeen Years).

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	85.32
Dried blood,	70.03
Sulfate of ammonia,	63.51

It will be noticed that, whatever the basis of comparison, the nitrate of soda has on the average given results considerably superior to those obtained either with manure or with either of the other nitrogen fertilizers. It will also be noticed that the sulfate of ammonia, on the other hand, has given results much inferior to those obtained with either of the other materials supplying nitrogen. If nitrogen, then, can be purchased in the form of nitrate at a price per unit not exceeding that which it will cost in other forms, there can be little doubt that it should be depended upon as a source of this element for most of the crops of the farm. The results of the past season, however, indicate that, as would naturally be anticipated, the nitrate does not show the same degree of superiority for corn as has usually been shown with the crops raised in this field, almost all of which complete their growth at a much earlier date in the season than corn.

II. — The Relative Value of Muriate and High-grade Sulfate of Potash. (Field B.)

In this experiment, muriate of potash is compared with the high-grade sulfate on the basis of such applications as will furnish equal actual potash per acre. These potash salts are used in connection with bone meal at the rate of 600 pounds per acre. The experiment was begun in 1892. During the first eight or nine years, potash salts were applied in varying quantities, but for the most part at the rate of about 350 to 400 pounds per acre. Since 1900, each has been applied annually at the rate of 250 pounds per acre. There are ten plots in the field, each containing about one-seventh of an acre. Five of these plots receive muriate of potash, and these plots alternate with the same number of plots which are yearly manured with sulfate of potash.

A large variety of crops has been grown in the different years during which this experiment has continued. The crops of the past year were asparagus, rhubarb, raspberries, blackberries, mixed hay, potatoes and soy beans. On each of plots 13 and 14 four different perennial crops are grown, namely, asparagus, rhubarb, raspberries and blackberries, each crop occupying substantially one-quarter of the area. The hay crop occupied four plots, the potatoes and soy beans two each.

No accidental conditions were observed which unfavorably influenced any of the crops. It is believed that the differences shown by the table giving the yields are due to the difference in potash salt employed. The rates of yield per acre of the various crops on the different fertilizers are presented in the following table: —

Crops.	Fertilizer used.	Plots.	Yield per Acre.	
			Beans.	Straw.
Soy beans,	Muriate of potash,	11	23.83 bush.	2,419 lbs.
	Sulfate of potash,	12	28.44 bush.	2,887 lbs.
Asparagus,	Muriate of potash,	13	2,649.7 lbs.	
	Sulfate of potash,	14	1,730.3 lbs.	
			Stalks.	Leaves.
Rhubarb,	Muriate of potash,	13	23,999 lbs.	20,733 lbs.
	Sulfate of potash,	14	40,992 lbs.	33,148 lbs.
Raspberries,	Muriate of potash,	13	57.26 lbs.	
	Sulfate of potash,	14	151.82 lbs.	
Blackberries,	Muriate of potash,	13	266.00 lbs.	
	Sulfate of potash,	14	857.90 lbs.	
			Hay.	Rowen.
Hay,	Muriate of potash,	15	2,438 lbs.	2,000 lbs.
	Sulfate of potash,	16	2,261 lbs.	1,911 lbs.
Hay,	Muriate of potash,	17	2,045 lbs.	1,981 lbs.
	Sulfate of potash,	18	2,709 lbs.	2,046 lbs.
			Large.	Small.
Potatoes,	Muriate of potash,	19	158.1 bush.	25.2 bush.
	Sulfate of potash,	20	180.8 bush.	28.5 bush.

Soy Beans. — The yield of soy beans, as will be noticed, was considerably larger upon the sulfate of potash. We have now carried through a similar experiment with soy beans fifteen times. In seven of these trials the result has been favorable to the sulfate of potash, and in one it was the same on the two salts. The average of all trials is favorable to the sulfate, and it would seem that there can be little doubt that where the two potash salts are continuously used the sulfate rather than the muriate should be selected. The superiority in yield on the former is usually much more than sufficient to cover the small additional cost of that salt, as compared with the muriate.

Asparagus. — It will be noticed that the yield of asparagus on the muriate of potash is more than 50 per cent. greater than on the sulfate. This result in so far as it goes appears to furnish evidence that the customary practice of depending largely upon the muriate as a source of potash for the asparagus crop is sound.

Rhubarb. — The yield of rhubarb this year is much larger than in any preceding year during which this crop has been grown in this experiment. In the earlier years the yield on the sulfate of potash has been moderately greater than on the muriate; this year it is very much greater, exceeding the yield on the muriate by about 80 per cent. Should further experiment support the evidence afforded thus far by this, it would appear that rhubarb growers in general will be wise to depend upon the sulfate rather than the muriate as a source of potash for that crop.

Raspberries and Blackberries. — The yield of both these crops is small on both fertilizers, that of raspberries especially so. During the three or four years the experiment on these plots has continued, the sulfate has invariably given better results than the muriate. Particularly noticeable has been the difference in the degree of winter-killing. The canes upon the plot to which muriate of potash is applied seem to be much less hardy than those on the plot where sulfate is used; and, with little doubt, the greater yield on the latter potash salt is mainly a consequence of the fact that the injury due to winter-killing is so much less.

Should further experiment confirm what now appears to be probable in regard to the varying effect of these two potash salts upon the ability of the canes of these fruits to resist the winter's cold, the point demonstrated will be one of much importance, for winter-killing is one of the most serious obstacles to the successful production of some of the most desirable varieties of these fruits.

The Hay Crops. — The hay crop of the past year occupied four plots. Clover seed alone was sown, but the clover did not make a good stand, and the vacancies were filled in part by timothy, in part by weeds. Where the clover was best, a considerable superiority in favor of the sulfate of potash was manifest. Aside from this observation, the results of the year with the hay crop did not appear to have much significance.

Potatoes. — It will be noted that the yield of merchantable potatoes upon the sulfate of potash was materially larger than on the muriate. This result is in accordance with the results which have usually been obtained in experiments upon our grounds; and, in spite of the fact that the season during which the potatoes made their chief growth was this year characterized by a considerable deficiency of rainfall, the soil where the sulfate has been continuously used shows its superiority over that where the muriate has been similarly used.

III. — COMPARISON OF DIFFERENT POTASH SALTS FOR FIELD CROPS. (FIELD G.)

This experiment is designed to show the ultimate effect upon the soil, as well as the current effect upon the crops, of continuous use of different potash salts. We have under comparison kainit, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and silicate. The field includes forty plots, in five series of eight plots each. Each series includes a no-potash plot, as well as the seven potash salts which have been named. The experiment is therefore carried out each year in quintuplicate. The area of each plot is one-fortieth of an acre. The potash salts under comparison are used in quantities which will supply annually actual potash at the rate of 165 pounds per acre to each of the plots. All plots are equally manured, and liberally, with materials furnishing nitrogen and phosphoric acid.

The crops which have been grown in this field in the order of their succession beginning in 1898 have been as follows: —

1898. Medium Green soy beans.
1899. Potatoes.
1900. Plots 1–8, cabbage; 9–24, Medium Green soy beans; 25–40, cowpeas.
1901. 1–8, wheat; 9–40, corn.
1902. Clover.
1903. Clover.
1904. 1–16, cabbage; 17–40, corn.
1905. Soy beans.
1906. Potatoes.

The results last year with the soy bean seemed rather inconclusive, on account of the number of variations due to exceptional conditions not necessarily connected with the varying use of potash salts. In brief, it may be stated that the plots to which kainit was applied gave the smallest average crops in the field, the yield being less even than on the no-potash plots. Carbonate of potash gave the highest average yield, followed closely by high-grade sulfate and silicate, while the yields on nitrate, muriate and low-grade sulfate were not much inferior.

The crop of the past season was potatoes. The variety grown was the Green Mountain, the seed having been purchased in Maine. One accidental variation must here be recorded, viz., that the quantity of Green Mountain seed proved to be slightly less than was needed, so that it was necessary to use another variety, Carmen No. 3, also from Maine, on one of the plots (40). The seed potatoes were treated with formalin at the rate of 1 pint to 15 gallons of water in the usual way on May 7. The field was plowed on May 8. On May 10, 2,427 pounds of freshly slaked lime were applied. This was harrowed in on May 11. On May 12, fertilizers were applied and harrowed in on the same day. On the same date, also, one-half the plots, four series, 1-20, were planted. On May 14, the balance of the field was planted. The crop was carefully cared for throughout the entire season. The vines were repeatedly sprayed with Bordeaux mixture, and carefully protected from bugs by the customary measures. Early in the season the vines on the no-potash plots showed a marked inferiority in growth. They were characterized by a dark, bluish-green color. The vines on the plots receiving chlorides in any form showed a distinctly lighter shade of green (pea green) than those manured with other potash salts. The vines on the silicate of potash plots were very dark in color, and somewhat resembled in general appearance, though much larger in growth, the vines on the no-potash plots.

The yields per plot and the rates of yield per acre are shown in the following table: —

Plots.	Potash Salt.	Pounds per Plot.		Bushels per Acre.	
		Large.	Small.	Large.	Small.
1, . .	No potash, ...	305.25	106.50	203.50	71.00
2, . .	Kainit, ...	424.75	83.75	283.16	55.83
3, . .	High-grade sulfate, ...	428.50	74.50	285.66	49.66
4, . .	Low-grade sulfate, ...	407.00	65.00	271.33	43.33
5, . .	Muriate, ...	439.75	74.00	293.16	49.33
6, . .	Nitrate, ...	412.75	71.50	275.16	47.66
7, . .	Carbonate, ...	374.25	94.50	249.50	63.00
8, . .	Silicate, ...	362.25	63.75	241.50	42.50
9, . .	No potash, ...	280.25	45.00	186.83	30.00
10, . .	Kainit, ...	340.00	47.00	226.66	31.33
11, . .	High-grade sulfate, ...	351.00	49.00	234.00	32.66
12, . .	Low-grade sulfate, ...	360.25	47.25	240.66	31.50
13, . .	Muriate, ...	332.50	53.00	221.66	35.33
14, . .	Nitrate, ...	350.75	37.00	235.50	24.66
15, . .	Carbonate, ...	313.50	76.00	209.00	50.66
16, . .	Silicate, ...	337.75	58.50	225.16	39.00
17, . .	No potash, ...	172.50	44.50	115.00	29.66
18, . .	Kainit, ...	231.25	33.25	154.16	22.66
19, . .	High-grade sulfate, ...	267.00	38.00	178.00	25.33
20, . .	Low-grade sulfate, ...	247.50	36.75	166.66	24.50
21, . .	Muriate, ...	269.50	40.00	179.66	26.66
22, . .	Nitrate, ...	241.50	55.50	161.00	37.00

Plots.	Potash Salt.	Pounds per Plot.		Bushels per Acre.	
		Large.	Small.	Large.	Small.
23, . .	Carbonate, ...	252.25	81.25	168.66	54.16
24, . .	Silicate, ...	235.25	61.25	156.83	40.33
25, . .	No potash, ...	135.50	50.50	90.33	33.66
26, . .	Kainit, ...	264.75	29.00	176.50	19.33
27, . .	High-grade sulfate, ...	278.75	35.50	185.83	23.66
28, . .	Low-grade sulfate, ...	330.25	36.25	220.16	24.16
29, . .	Muriate, ...	320.25	47.50	213.50	31.66
30, . .	Nitrate, ...	285.75	58.75	190.50	39.16
31, . .	Carbonate, ...	335.00	76.50	223.33	51.00
32, . .	Silicate, ...	254.25	74.25	167.83	49.50
33, . .	No potash, ...	167.00	46.00	111.33	30.66
34, . .	Kainit, ...	292.00	39.00	194.66	26.00
35, . .	High-grade sulfate, ...	307.25	41.00	204.83	27.33
36, . .	Low-grade sulfate, ...	310.00	44.00	206.66	29.33
37, . .	Muriate, ...	315.75	73.00	210.50	48.66
38, . .	Nitrate, ...	321.75	49.00	214.50	32.66
39, . .	Carbonate, ...	298.25	70.00	198.83	46.66
40, . .	Silicate, ...	312.00	59.00	208.00	39.33

The average yields under the varying fertilizer treatments are as follows: —

Potatoes. — Average Yields per Acre (Bushels).

Potash Salt.	Large.	Small.
No potash (plots 1, 9, 17, 25, 33), ...	141.40	39.00
Kainit (plots 2, 10, 18, 26, 34), ...	207.03	31.03
High-grade sulfate (plots 3, 11, 19, 27, 35), ...	217.66	31.73
Low-grade sulfate (plots 4, 12, 20, 28, 36), ...	221.09	30.56
Muriate (plots 5, 13, 21, 29, 37), ...	223.70	38.33
Nitrate (plots 6, 14, 22, 30, 38), ...	215.33	36.23
Carbonate (plots 7, 15, 23, 31, 39), ...	209.86	53.10
Silicate (plots 8, 16, 24, 32, 40), ...	199.86	42.13

It will be noticed that the no-potash plots on the average give a yield much inferior to that produced on the plots receiving potash. The best average yield is produced by the muriate, but the differences between the yield on this potash salt and the average yield produced by the low-grade and high-grade sulfate and the nitrate are small. Carbonate ranks next, followed by kainit and silicate. The past season (June 1 to August 15) was characterized by rainfall considerably below the average. Previous experiments have shown that in such seasons muriate of potash can usually be depended upon to give crops equal to those produced where the sulfates are used. Lime, moreover, is known to offset in a measure the unfavorable results consequent upon continued use of muriate; and the entire field, as stated, was limed this season.

We are unable at this time to make a report in relation to the quality of the tubers produced on the different fertilizers, but the different lots have been carefully sampled, and such a report will be made later.

The Effect of the Liming. — Attention is called to the fact that in using lime immediately preceding the potato crop we departed from the usually accepted rule. Such use of lime is not regarded as desirable on account of the chances that the immediately following crop of potatoes will be scabby. This result was noted upon a portion of the plots in this field, principally 1 to 8. The amount of scab, however, was not on the whole serious.

The Relation of the Potash to Potato Blight. — As has been stated in the description of the general care given the crop, the potatoes in this field were repeatedly and carefully sprayed with Bordeaux mixture. The dates of the successive applications were as follows: June 27, July 7, August 2–3, August 10. Early in August it was noticed that the leaves of all the no-potash potato plants were beginning to blight, while the foliage on all the plots to which potash has been annually applied still appeared to be practically unaffected. The blight made rapid progress on each of the five no-potash plots, while the foliage of the vines upon all the other plots for the most part ripened normally. Practically all the leaves on the no-potash plots were dead by the end of August, at which date there was still considerable living foliage on the other plots. There was no decay of the tubers, however, on any of the plots; but the marked inferiority in yield on the no-potash plots was no doubt in considerable measure due to the relatively early death of the foliage.

No explanation can be offered at this time for the observed phenomena. Earlier observers, among them Dr. Goessmann and Professor Maynard, have held that a liberal supply of potash has in some cases exercised a marked influence in enabling the foliage of fruits to resist fungous diseases. Some European investigators have attributed a similar effect to potash in connection with potato diseases. This matter should evidently receive further and most careful study, for, if potato blight can be in a measure controlled through more liberal use of potash salts, this will afford a comparatively easy method of reducing the amount of injury due to the fungi attacking the foliage of this important crop.

IV. — NORTH CORN ACRE. — SPECIAL FERTILIZER *v.* FERTILIZER RICHER IN POTASH.

This experiment was begun in 1891. It occupies an acre of ground, divided into four equal plots. Plots 3 and 4 were sown to millet during the first two years of the experiment, but with this exception their treatment has been the same as that of plots 1 and 2, 3 being a duplicate of 1, and 4 a duplicate of 2, both as regards fertilizer application and crops produced. During the period under consideration the entire area with the exception noted for plots 3 and 4, has been in corn, with the exception of three two-year periods, 1897 and 1898, 1899 and 1900, and the past two years, during which periods the land has been in mixed grass and clover. The method of seeding in every instance has been by sowing in the corn of the year preceding the first of each of the three two-year periods during which hay has been the crop.

The object in this experiment is to test the question whether the special corn fertilizers offered in our markets are of such composition as seems to be best suited for the production of corn and mixed hay in rotation. Plots 1 and 3 have yearly received an application of fertilizers (a home mixture) furnishing per acre the same amount of nitrogen, phosphoric acid and potash as would be furnished by 1,800 pounds of fertilizer having the composition of the average of the special corn fertilizers analyzed at this station. This average changes but little from year to year, and in 1899, since which date we have made no change in the kinds and amounts of fertilizers used, it was as follows: —

	Per Cent.
Nitrogen,	2.37
Phosphoric acid,	10.00
Potash,	4.30

The averages for the past year have been: nitrogen, 2.61 per cent.; phosphoric acid, 11.55 per cent.; and potash, 4 per cent.

The fertilizers which have been used on plots 2 and 4 are substantially the same in amount and kind as were recommended for corn in Bulletin No. 58 (Hatch). The essential difference in the fertilizer mixtures under comparison is that the mixture used on plots 2 and 4 is richer in potash and much poorer in phosphoric acid than the mixture representing the average market corn fertilizers. The difference in the application of the fertilizer elements is shown in the following table: —

Fertilizer Elements applied annually.

PLOTS.	RATES PER ACRE (POUNDS).		
	N	P_2O_5	K_2O
Plots 1 and 3,	42.6	180	77.4
Plots 2 and 4,	47.0	50	125.0

The fertilizer materials applied to the several plots annually are shown below: —

FERTILIZERS USED.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4 (Pounds Each).
Nitrate of soda,	30.0	50.0
Dried blood,	30.0	–
Dry ground fish,	37.5	50.0
Acid phosphate,	273.0	50.0
Muriate of potash,	37.5	62.5

This field was limed in 1900 at the rate of 1 ton to the acre.

The crop of the past season was mixed grass and clover, the present being the second year for this seeding. The rates of yield per acre on the several plots and the averages for the two systems of manuring are shown by the following tables: —

Yields per Acre (Pounds).

PLOTS.	Hay.	Rowen.
Plot 1 (lesser potash),	2,600	1,680
Plot 2 (richer in potash),	2,320	1,480
Plot 3 (lesser potash),	2,980	1,300
Plot 4 (richer in potash),	2,400	2,020

Average Yields per Acre (Pounds).

PLOTS.	Hay.	Rowen.
Plots 1 and 3 (lesser potash),	2,790	1,490
Plots 2 and 4 (richer in potash),	2,360	1,750

It will be noticed that the combination of fertilizers representing the special corn fertilizer gives an average yield of hay at the rate of 430 pounds per acre heavier than that produced where the combination of fertilizer materials richer in potash was used. On the other hand the latter combination of fertilizer materials gives a yield of rowen averaging 260 pounds per acre greater than the special corn fertilizer. The total crops, then, produced under the two systems of fertilizing, are not far from equal for the past year.

Since this experiment was begun, this land has produced on plots 1 and 2, ten corn crops; on plots 3 and 4, eight corn crops. The average yields per plot and the averages for the two systems of fertilizing are shown in the following tables: —

Average Yields of Corn per Acre.

PLOTS.	Corn (Bushels).	Stover (Pounds).
Ten Years.		
Plot 1 (lesser potash),	56.77	4,596
Plot 2 (richer in potash),	51.98	4,640
Eight Years.		
Plot 3 (lesser potash),	55.18	4,371
Plot 4 (richer in potash),	52.99	4,590

Average Yields per Acre on the Two Systems of Fertilizing.

PLOTS.	Corn (Bushels).	Stover (Pounds).
Plots 1 and 3 (lesser potash),	55.98	4,484
Plots 2 and 4 (richer in potash),	52.48	4,615

During the period of this experiment the entire field has produced six crops each of hay and rowen. The averages for each plot and the averages for the two systems of fertilizing are shown in the following tables: —

Average Yields per Acre of Hay and Rowen, Six Years (Pounds).

PLOTS.	Hay.	Rowen.
Plot 1 (lesser potash),	3,655	1,100
Plot 2 (richer in potash),	3,785	1,176
Plot 3 (lesser potash),	3,459	885
Plot 4 (richer in potash),	3,607	1,203

Average Yields per Acre on the Two Systems of Fertilizing, Six Years (Pounds).

PLOTS.	Hay.	Rowen.
Plots 1 and 3 (lesser potash),	3,557	993
Plots 2 and 4 (richer in potash),	3,696	1,152

It will be noticed that the average crop of corn has been somewhat heavier, while the average crop of hay is slightly less, on the combination of materials representing the special corn fertilizer. The crops of corn stover and of rowen have been greater on the combination of materials furnishing more potash. This is in accordance with what is to be expected, as the potash is found almost invariably to favor a large proportion of clover in mixed mowings, and as it has been shown in the results of many experiments in this State that stover is increased in larger proportion through application of potash than is the grain.[1]

At the prices which have prevailed during the period of the experiment, the cost per acre of the fertilizers used on plots 2 and 4 has averaged about $5 less than the cost of the materials used on plots 1 and 3. Taking the crops as a whole, they have been substantially equal under the two systems of fertilizing; and the advantage, therefore, is clearly with the fertilizer combination richer in potash, unless it can be shown that the condition of the soil upon plots 2 and 4 is now inferior to that of the soil on plots 1 and 3. Such inferiority is not indicated by the present relative yields. Neither does a study of the income and outgo from the soil of fertilizer elements upon the several plots point in that direction. Calculations made at the close of 1905 to determine the fertilizer ingredients supplied and removed from the several plots gave the following results: —

PLOTS.	FERTILIZER INGREDIENTS.					
	SUPPLIED.			REMOVED.		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Plot 1 (lesser potash),	135.10	537.94	216.00	331.08	117.74	228.46
Plot 2 (richer in potash),	117.55	217.63	470.00	322.44	114.32	229.79
Plot 3 (lesser potash),	135.10	537.94	216.00	259.52	93.37	180.26
Plot 4 (richer in potash),	117.55	217.63	470.00	307.38	109.97	234.27

A study of the figures of the above table indicates that on every plot a much larger quantity of nitrogen has been removed from the soil than has been supplied in the fertilizers used. The large excess of nitrogen removed can be accounted for only as a result of the frequent introduction of clover in the rotation.

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[1] Bulletin No. 9 and Bulletin No. 14, Hatch Experiment Station.

It will be noticed that on plots 1 and 3 phosphoric acid has been applied in the fertilizers used in quantity on the average more than five times greater than the quantity removed. Even on plots 2 and 4 phosphoric acid has been supplied in quantity practically double that removed.

Potash on one of the plots (1 and 3) has been supplied in slightly larger quantity than removed, while on the other plot the quantity removed is slightly in excess of the quantity supplied.

On the average, the condition of the soil as regards this element on plots 1 and 3 cannot be materially different from what it was at the beginning of the experiment. On plots 2 and 4, on the other hand, potash has been supplied in quantity a little more than double that removed.

V. — South Corn Acre. — Manure Alone *v.* Manure and Potash.

The object in view in this experiment is to compare the crop-producing capacity of manure alone applied in fairly liberal amounts with a combination of a lesser amount of manure and a moderate quantity of a potash salt. An acre of land is used in the experiment. It is divided into four plots, of one-quarter acre each. Two of the plots (1 and 3) have received applications of manure only; the other two plots (2 and 4) have been fertilized by applications of lesser amounts of manure, together with a potash salt.

This experiment was begun in 1891. The crop for the first six years was corn. Corn was raised also in 1899 and 1900, and in 1903 and 1904. The field has been put into mixed grass and clover three times, being seeded in the summer preceding the first year of cutting in the corn crop. Each time that the land has been seeded it has been cut twice annually for two years. The sod has then been broken in the fall for the corn crop of the following year. The years when the field has been in mowing are 1898 and 1899, 1901 and 1902, and 1905 and 1906.

Manure has been applied to plots 1 and 3 every year, at the rate of 6 cords per acre, with the following exceptions. No manure was applied in 1897, 1902 and 1905, and in 1898 the amount applied was at the rate of 4 cords per acre. The reason for the omission of manure in the years mentioned and for the smaller amount in 1898 was that experience indicated that its application would cause the grass and clover to lodge badly.

Manure has been applied to plots 2 and 4 as follows: in 1891 and 1892, at the rate of 3 cords per acre; in 1898, at the rate of 2 cords per acre; while in 1897, 1902 and 1905 no manure was applied. In all other years the application has been at the rate of 4 cords per acre. Potash has been applied to plots 2 and 4 at the rate of 160 pounds per acre of high-grade sulfate annually, except in the years when no manure was applied. In these years the potash also was withheld.

The entire field was limed in 1900, at the rate of 1 ton per acre. The manure applied has been that made by well-fed milch cows, and carefully preserved. It has usually weighed about 3 tons per cord. Both manure and fertilizer have been applied broadcast after plowing, and harrowed in.

The crop of the past season was mixed grass and clover, this being the second year, as above indicated. The manure was applied with a spreader on May 2. The high-grade sulfate was applied broadcast by hand, and this year, by mistake, it was applied to plots 1 and 3 as well as to plots 2 and 4.

The following tables show the rates of yield on the several plots and the averages under the two systems of manuring: —

Yields Per Acre, 1906 (Pounds).

PLOTS.	Hay.	Rowen.
Plot 1 (manure alone), ...	3,880	2,640
Plot 2 (manure and potash), ...	3,200	2,384
Plot 3 (manure alone), ...	3,592	2,396
Plot 4 (manure and potash), ...	3,180	2,416

Average Yields per Acre (Pounds).

PLOTS.	Hay.	Rowen.
Plots 1 and 3 (manure alone), ...	3,736	2,518
Plots 2 and 4 (manure and potash), ...	3,190	2,400

It will be noticed that the hay crop on the combination of manure and potash is less than on the larger quantity of manure alone in both cases, the average difference being at the rate of 646 pounds per acre. The rowen crops are more nearly equal, the average difference amounting to only 118 pounds per acre in favor of the larger application of manure. The heavier application of manure means, of course, a larger application of nitrogen. It is not surprising, therefore, that the first crop, which includes a considerable proportion of timothy and redtop, is heavier where the manure is most largely used. The rowen crop is made up in much larger proportion of clover, and the proportion of clover is greater where the lesser quantity of manure and the potash salt are applied. Estimating the manure to cost on the land $5 per cord and the high-grade sulfate of potash at the market rates, the usual annual difference in cost of materials applied has amounted to about $6 to $6.50 per acre, the lesser amount of manure and potash costing about that amount less than the larger application of manure.

This experiment has now continued sixteen years. During this time ten corn crops have been raised. The average yields per plot and the averages for the two systems of manuring are shown in the following tables: —

Average Yields per Acre.

PLOTS.	Corn (Bushels).	Stover (Pounds).
Plot 1 (manure alone), ...	62.32	4,929
Plot 2 (manure and potash), ...	58.48	4,579
Plot 3 (manure alone), ...	61.29	4,292
Plot 4 (manure and potash), ...	57 54	4,104

Average Yields per Acre on the Two Systems of Manuring, Ten Crops.

PLOTS.	Corn (Bushels).	Stover (Pounds).
Plots 1 and 3 (manure alone),	61.81	4,611
Plots 2 and 4 (manure and potash),	58.01	4,342

It will be noticed that the average yield on plots 2 and 4 (lesser manure and potash) has been at the rate of about 3.8 bushels per acre less than on the larger quantity of manure alone.

During six years the experimental acre has been in mixed grass and clover. The following tables show the average results per plot and the averages for the two systems of manuring: —

Average Yields per Acre of Hay Crop, Six Years (Pounds).

PLOTS.	Hay.	Rowen.
Plot 1 (manure alone),	5,197	2,569
Plot 2 (manure and potash),	4,370	2,103
Plot 3 (manure alone),	4,970	2,546
Plot 4 (manure and potash),	4,923	2,415

Average Yields per Acre on the Two Systems of Manuring, Six Years (Pounds).

PLOTS.	Hay.	Rowen.
Plots 1 and 3 (manure alone),	5,084	2,558
Plots 2 and 4 (manure and potash),	4,647	2,259

It will be noticed that the average difference against the lesser quantity of manure and potash amounts to a little more than 400 pounds of hay and slightly less than 300 pounds of rowen per acre annually.

The differences indicated by the averages shown in the above tables, whether for corn or hay, are not sufficient to offset the greater cost of the heavier application of manure.

At the end of last year, calculations based in part upon analyses, and in part upon average figures for the composition of the crops raised, gave results presented in the following tables for the totals of plant food applied and removed in the several plots: —

PLOTS.	FERTILIZER INGREDIENTS.					
	SUPPLIED.			REMOVED.		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Plot 1 (manure alone), ...	425.41	330.69	511.51	394.07	138.74	282.60
Plot 2 (manure and potash), . .	291.09	229.98	543.68	361.22	127.91	256.64
Plot 3 (manure alone), ...	449.96	330.94	500.76	373.34	132.10	262.21
Plot 4 (manure and potash), . .	281.10	233.37	549.56	355.02	126.26	250.82

It will be noticed that on plots 1 and 3 the amounts of nitrogen applied in the manure show a moderate excess above the amount removed in the crops. On the other hand, the application of nitrogen to plots 2 and 4 (lesser manure and potash) is materially less than the amount removed. This result may have been rendered possible in one of two ways: first, the soil on these plots may have been depleted in part of its original store of nitrogen; second, the excess may have been taken from the air by the clover in the mixed hay crops grown during six of the sixteen years. As these plots show no indication of declining fertility, but, on the contrary, appear on the whole to be improving from year to year, the latter is with little doubt the correct explanation.

It will be noticed that under both systems of manuring we have applied phosphoric acid and potash in large excess above the amounts removed. In the case of plots 1 and 3, phosphoric acid has been applied in approximately two and one-half times the quantity removed; potash, in rather less than twice the quantity removed. In the case of plots 2 and 4, phosphoric acid has been applied in considerably less than twice the quantities removed; potash, in rather more than twice the quantities removed. In view of the fact that neither phosphoric acid nor potash is supposed to be lost to the soil to any considerable extent by leaching, the condition of the soil on all the plots as regards the stock of phosphoric acid and potash in available form must now be considerably better than at the beginning of the experiment; and there can be little doubt that a lesser application of these fertilizer elements in the immediate future will prove sufficient to give satisfactory crops.

VI. — COMPARISON OF PHOSPHATES ON THE BASIS OF EQUAL APPLICATION OF PHOSPHORIC ACID.

The past season is the tenth of this experiment, the object of which is to determine, as measured by crop production, the relative availability of different materials which may be used as sources of phosphoric acid. All these materials have from the first been applied in such quantities as to furnish phosphoric acid at the rate of 96 pounds per acre in the case of each of the materials under comparison. The field comprises thirteen plots, each containing one-eighth of an acre. Three of the plots have received no phosphoric acid since the experiment began. One of these is located at either end of the field, the third in the middle. The phosphates under comparison are the following: apatite (fine ground), South Carolina rock phosphate (fine ground), Florida soft phosphate, basic slag meal, Tennessee rock phosphate (fine ground), dissolved bone black, raw bone meal, dissolved bone meal, steamed bone meal and acid phosphate. Materials supplying nitrogen and potash liberally are applied to each of the plots annually, and in such quantities as to furnish nitrogen at the rate of 52 pounds and potash at the rate of 152 pounds per acre. In the case of a few crops requiring especially high manuring (onions and cabbages), a supplementary application of quick-acting nitrogen fertilizers has been made to all plots alike. Owing to the impossibility of procuring the material, no apatite was applied to plot 2 during the past season. The crops which have been grown in the field during the progress of the experiment are as follows: corn, cabbages, corn, in 1900 two crops, — oats and Hungarian grass (both for hay), onions, onions, cabbages, and mixed grass and clover. The field was seeded in the spring of 1905 without a nurse crop. It was cut twice during the season, but the product, largely mixed with weeds, was not weighed.

During the past season the field has been cut twice and the product made into hay. The following table gives the yield per plot, the rates of yield per acre, and the gain or loss as compared with the no-phosphate plots, both for the hay and rowen: —

Plots.	Fertilizers used.	Yield per Plot (Pounds).		Yield per Acre (Pounds).		Gain or Loss (Pounds).	
		Hay.	Rowen.	Hay.	Rowen.	Hay.	Rowen.
Plot 1, .	No phosphate, . . .	825	225	6,600	1,800	-	-
Plot 2, .	Apatite, ...	940	215	7,520	1,720	800	—147
Plot 3, .	South Carolina rock phosphate.	930	202	7,440	1,616	720	—251
Plot 4, .	Florida soft phosphate, .	950	188	7,600	1,504	880	—363
Plot 5, .	Phosphatic slag, . .	950	200	7,600	1,600	880	—267
Plot 6, .	Tennessee phosphate, .	890	203	7,120	1,624	400	—243
Plot 7, .	No phosphate, . . .	875	275	7,000	2,200	-	-
Plot 8, .	Dissolved bone black, .	870	280	6,960	2,240	240	+373
Plot 9, .	Raw bone, ...	890	250	7,120	2,000	400	+133
Plot 10, .	Dissolved bone meal, .	940	319	7,520	2,552	800	+685
Plot 11, .	Steamed bone meal, . .	890	283	7,120	2,264	400	+397
Plot 12, .	Acid phosphate, . .	885	290	7,080	2,320	360	+453
Plot 13, .	No phosphate, . . .	820	200	6,560	1,600	-	-

It will be noticed that both the first and second crops of hay were heavy, the first especially so. This crop had lodged considerably before it could be cut, and there is little doubt that the possible increase due to the fertilizers was somewhat diminished through the check in growth consequent upon the badly lodged condition. We do not find the application of the phosphates to have apparently influenced the yield either of hay or rowen to a very large extent. The results are in harmony with previous observations upon our soils, which have indicated them to require relatively small applications of phosphates for all crops except those belonging to the Cruciferæ, such as cabbages and turnips. In 1903, when this entire field was planted to cabbages, the yields wherever phosphates were annually applied greatly exceeded the average yield on the no-phosphate plots. The range on the several phosphate plots was from about two to five times the average product of the no-phosphate plots. This year, with a mixed crop, grass and clover, representing Gramineæ and Leguminosæ, the largest increase on any phosphate is only about 17 per cent. In other words, when cabbages were the crop, the increase was in some instances as great as 500 per cent., or nearly thirty times as great as this year.

VII. — Soil Tests.

Two soil tests have been carried out during the past year, both in continuation of previous tests upon the same fields. In these tests fertilizers have been applied in accordance with the co-operative plan for soil tests. Each plot annually receives an application of the same kind or kinds of fertilizers, and usually in the same amounts for each of the plots from year to year. Particular attention is called to the fact that this system of fertilization is not expected to secure the production of heavy crops. It does throw important light upon the specific effects of the different leading elements of plant food by themselves and in combination on the crops which are grown in succeeding years. Every fertilizer used, whether applied by itself or in connection with one or both of the other fertilizer materials, is always applied in the same quantities; and both fertilizers and manure, when the latter is introduced for purposes of comparison, are always applied broadcast after plowing, and harrowed in when a hoed crop is to be grown. When mixed hay is the crop the materials are applied broadcast, and must of course be left on the surface. The kinds of fertilizers and the rates per acre are as follows: —

Nitrate of soda, 160 pounds, furnishing nitrogen.
Dissolved bone black, 320 pounds, furnishing phosphoric acid.
Muriate of potash, 160 pounds, furnishing potash.
Land plaster, 400 pounds.
Lime, 800 pounds.
Manure, 5 cords.

The germination of the soy beans on the north acre was very irregular. The stand of plants as a consequence was so uneven that the results do not indicate with any clearness the effect of the different fertilizers. The figures will not, therefore, be reported in detail. The results, however, clearly indicated the beneficial results which have followed the use of lime in connection with the other fertilizers.

Soil Test with Corn (South Acre). — This acre has been used in soil tests for eighteen years, beginning in 1889. The field has been limed twice during this period, each time at the rate of 1 ton to the acre. The lime was applied broadcast after plowing, and harrowed in. These applications of lime were made respectively in 1899 and in 1904.

The crops for successive years have been as follows: corn, corn, oats, grass and clover, grass and clover, corn (followed by mustard as a catch crop), rye, soy beans, white mustard, corn, corn, grass and clover, grass and clover, corn, corn, corn, grass and clover, grass and clover. Since 1899 this field has, therefore, borne eight corn crops. Three times it has been put into mixed grass and clover, each time for two years. The past season is the second of the third two-year period. The season has been a fairly favorable one for grass, although, as the soil of this field is inclined to be light, there can be no doubt that a somewhat heavier yield would have been obtained had the rainfall been larger. The following table shows the fertilizers used on the several plots, the rates of yield and the gain or loss per acre, compared with the nothing plots: —

Grass and Clover. — South Acre Soil Test, 1906.

Plots.	Fertilizers used.	Yield per Acre (Pounds).		Gain or Loss per Acre, compared with Nothing Plots.	
		Hay.	Rowen.	Hay.	Rowen.
Plot 1, .	Nitrate of soda, ...	1,400	520	+490.0	+220.00
Plot 2, .	Dissolved bone black, . . .	760	295	—150.0	—5.00
Plot 3, .	Nothing, ...	910	300	-	-
Plot 4, .	Muriate of potash, ...	690	440	—136.7	+131.70
Plot 5, .	Lime, ...	890	260	+146.7	—56.70
Plot 6, .	Nothing, ...	660	325	-	-
Plot 7, .	Manure, ...	2,940	2,670	+2,226.7	+2,323.30
Plot 8, .	Nitrate of soda and dissolved bone black.	2,200	520	+1,433.3	+151.70
Plot 9, .	Nothing, ...	820	390	-	-
Plot 10, .	Nitrate of soda and muriate of potash.	2,400	470	+1,536.7	+73.33
Plot 11, .	Dissolved bone black and muriate of potash.	1,790	1,220	+883.3	+816.70
Plot 12, .	Nothing, ...	950	410	-	-
Plot 13, .	Plaster, ...	640	320	—310.0	—90.00
Plot 14, .	Nitrate of soda, dissolved bone black and muriate of potash.	3,000	1,100	+2,050.0	+1,690.00

It will be noticed that the yield on all the nothing plots is extremely small, — considerably less than one-half ton per acre. It will be noticed, further, that neither lime nor plaster used by itself produced an increase; indeed, the yield on both is lower than the average yield of the nothing plots. Nitrate of soda by itself produces a very small increase; in combination with either of the other fertilizer elements the increase is much larger, but it is best, as would naturally be expected, in combination with both the other fertilizer elements. It will be noted that the use in combination of dissolved bone black and muriate of potash gives a considerable increase in the crop. This increase shows itself almost as plainly in the rowen as in the first crop, as a consequence, of course, of the relatively large proportion of clover which follows continuous use of materials supplying phosphoric acid and potash without nitrogen. The average results obtained in the six years during which this field has been in hay will be of interest. They are shown in the following table: —

Average Increases in Six Hay and Rowen Crops.

	Averages of Nothings.	Nitrate.	Bone Black.	Muriate.	Lime.	Manure.
Hay, ...	853.8	722.5	—100.0	152.6	120.0	2,579.2
Rowen, ...	604.4	743.3	+52.5	632.0	108.8	2,357.2
Totals, . . .	1,458.1	1,465.8	—47.5	784.5	228.8	4,936.4

Average Increases in Six Hay and Rowen Crops — Concluded.

	Nitrate and Bone Black.	Nitrate and Muriate.	Bone Black and Muriate.	Plaster.	Nitrate, Bone Black and Muriate.
Hay, ...	1,183.3	1,474.2	1,113.3	—275.5	2,092.5
Rowen, ...	430.3	565.5	952.8	—221.8	878.3
Totals, . . .	1,513.6	2,039.7	2,066.2	—497.2	2,970.8

This table affords conclusive evidence that hay can be grown at a profit on fertilizers alone, although naturally the increases produced by the very moderate applications of fertilizers used in this experiment are not equal to those produced by the annual application of manure. The latter, however, at $5 per cord on the land costs annually at the rate of $25 per acre; the combination of dissolved bone black and muriate of potash costs annually at the rate of about $6 per acre; while the annual application of all three fertilizer elements costs at the rate of about $10 to $11 per acre.

VIII. — EXPERIMENT IN MANURING GRASS LAND.

The plan of this experiment, which was begun in 1893, is fully outlined in the sixteenth annual report. From that report I quote: —

> In this experiment, which has continued since 1893, the purpose is to test a system of using manures in rotation for the production of grass. The area used in the experiment is about 9 acres. It is divided into three approximately equal plots. The plan is to apply to each plot one year barnyard manure, the next year wood ashes, and the third year, fine-ground bone and muriate of potash. As we have three plots, the system of manuring has been so arranged that every year we have a plot illustrating the results of each of the applications under trial. The rates at which the several manures are employed are as follows: barnyard manure, 8 tons; wood ashes, 1 ton; ground bone, 600 pounds; and muriate of potash, 200 pounds, per acre. The manure is always applied in the fall; ashes and the bone and potash in early spring.

The past season, which showed a considerable deficiency in rainfall during the months when a liberal supply of moisture is highly important for the hay crop, was unfavorable to large yields, and the product of the past season falls considerably below the average product for the period of the experiment. The yields of hay and rowen and the total yields for each system of manuring were at the following rates per acre: —

FERTILIZERS USED.	Hay (Pounds).	Rowen (Pounds).	Total (Pounds).
Barnyard manure, ...	2,892	1,063	3,955
Bone and potash, ...	2,420	1,396	3,816
Wood ashes, ...	2,932	1,240	4,172

The average for the entire area this year was 4,902 pounds. The average yield of the entire area from 1893 to 1905, inclusive, was 6,572 pounds. Including the crop of the past season, the average for the entire period, 1893 to the present time, is 6,389 pounds. The average yields to date under the different systems of top-dressing have been as follows: —

	Pounds per Acre.
When top-dressed with manure, ...	6,658
When top-dressed with wood ashes, . . .	6,059
When top-dressed with bone and potash, . . .	6,331

IX. — Experiment in the Application of Manure.

This experiment was planned to be continued through a series of years, with a view to throwing light upon the question as to the best method of handling farm manures. The field in use has an area of a little less than three acres, and slopes moderately to the west. It had been divided into five plots a number of years previous to the beginning of this experiment, for the comparison of different fertilizers. Each of these five plots was subdivided into two sub-plots. To one of these sub-plots in each of the five pairs the manure is applied during the winter, being spread upon the surface as it is hauled to the field; to the other sub-plot in each of the five pairs the manure as it is hauled is put into a large, compact heap. The manure used is carefully preserved, from well-fed dairy cows on four of the pairs of plots (1, 2, 3 and 4), and purchased stable manure from horses on one pair of plots (5). The experiment is so managed that all the manure is hauled for a single pair of plots at one time, usually during a single day, or at most within two days. To insure even quality of the manure on the two sub-plots, loads are placed alternately on the north half, where it is spread as hauled; and on the south half, where, as has been stated, it is put into a large heap. The land has usually been plowed late in the fall. The manure has usually been applied to the two sub-plots 1 early in the winter; to the sub-plots 2, 3 and 4 respectively at intervals each about one month later than the preceding. The manure which is placed in the heaps remains there until it is time to prepare the soil for planting in the spring. It is then spread, and as soon as convenient the entire area, including both the winter and the spring applications, is plowed. It is estimated that the double handling of the manure required in the case of that portion which is applied in the spring costs at the rate of $4.80 per acre more than the single handling where the manure is spread when hauled during the winter.

The experiment was begun in 1899; the present season, therefore, is the eighth during which the experiment has been continued. The crop of the past season was corn. Fourteen different varieties of seed were used. The different plots, however, were so planted that each contained equal areas of each variety. The fact that a number of varieties was used is mentioned only because it is a partial explanation of the fact that the yield in this field is considerably lower than is usual in this vicinity on well-manured land. This inferiority in yield was due to the fact that many of the varieties which we had been asked to test by the United States Department of Agriculture proved comparatively worthless. The rates of yield per acre and the relative standing of the several plots are shown in the following tables: —

Corn and Stover. — Actual Yields (Rates per Acre).

PLOTS.	NORTH HALF, WINTER APPLICATION.			SOUTH HALF, SPRING APPLICATION.		
	Stover (Pounds).	Hard Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).	Hard Corn (Bushels).	Soft Corn (Bushels).
Plot 1,	3,741	36.43	5.86	3,961	38.61	5.65
Plot 2,	3,414	30.50	4.64	3,893	37.48	4.99
Plot 3,	3,563	35.72	5.34	3,847	38.73	5.05
Plot 4,	3,171	32.13	5.01	3,143	29.95	5.61
Plot 5,	3,401	31.22	4.32	3,457	31.91	4.13

Corn and Stover. — Relative Yields (Per Cent.).

PLOTS.	NORTH HALF, WINTER APPLICATION.		SOUTH HALF, SPRING APPLICATION.	
	Stover.	Hard Corn.	Stover.	Hard Corn.
Plot 1,	100	100	105.7	104.7
Plot 2,	100	100	114.0	122.9
Plot 3,	100	100	107.8	108.4
Plot 4,	100	100	99.1	93.2
Plot 5,	100	100	101.6	102.2

It will be noticed that in every instance the spring application of manure has given a larger yield both of stover and of hard corn than the winter application, except on plot 4. This exception, in our judgment, is due to the fact that during the early part of the season it was comparatively rainy, and a part of the area on the south half of plot 4 was over wet, so that the seed germinated imperfectly. The results of this year, then, although naturally not showing precise numerical agreement, are in entire accord with those obtained in 1905. During the entire period that the experiment has continued the results as a rule have been similar.

It has been noticed that the degree of superiority of the crops on the sub-plots where the manure was spread in the spring has varied with the character of the preceding winter. There is evidently some loss in manurial value through the exposure of the manure throughout the winter, and this loss is probably for the most part due to wash over the frozen ground during the winter or early spring. It has been found that in a season following a cold winter, where snow has covered and protected the manure during practically all the time, and where there has been a minimum of water flowing over the surface, the winter-applied manure has given results closely approaching those upon the manure applied in the spring. It is manifestly impossible to foresee the character of the approaching winter months, and so there must always be a degree of uncertainty as to results. Taken as a whole, however, the differences obtained in our experiments in favor of spring application have been relatively small, and during a large proportion of the time insufficient in value to cover the extra cost of the double handling.

In estimating the significance of our results, it should be kept in mind that the field on which these experiments have been tried has a considerable slope. It is, therefore, of such a character as is favorable to considerable waste through surface wash, whenever the conditions are such as to make such wash possible. It is not believed that on land which is substantially level, and which can be fall plowed, the amount of waste due to the exposure incident to surface application in winter will be sufficiently great to make it good farm economy to give the manure the double handling involved in the spring application. If the storage for manure is sufficient, so that it can be safely held where made until spring, application at that season will undoubtedly be safest on most of our New England farms, where the surfaces of the fields are usually far from level. With level fields, on the other hand, application of manure during the winter would seem to be the better farm practice.

X. — Nitrate of Soda for Rowen.

The station has been experimenting for a number of years, with a view to noting whether nitrate of soda applied soon after the first crop is cut will give a profitable increase in the rowen crop. The field in which most of our experiments have been tried was seeded to pure timothy in the fall of 1897. The crop is now considerably mixed with clover (mostly white), which has been gradually coming in. For the first crop we apply fertilizers at the following rates per acre: nitrate of soda, 150 pounds; muriate of potash, 200 pounds; fine-ground bone, 400 pounds. The total area of the field is a little more than three acres. The rate of yield of the first crop this year was 3,153 pounds per acre, which is considerably less than the average product since the field was seeded. For the purpose of the experiment with nitrate of soda, eight equal plots have been laid off, each containing almost exactly one-third of an acre. During the past six years alternate plots in this series of eight have annually received a top-dressing of nitrate of soda. For the past three years, in order that this may be more uniformly spread, we have mixed the nitrate of soda for each plot with such a quantity of basic slag meal as to constitute an application of the latter at the rate of 400 pounds per acre. To equalize conditions on the alternate plots to which no nitrate is applied, the slag meal is applied to all of these at the same rate. The application of fertilizers to the several plots and the rates of yield per acre are shown in the following table: —

Nitrate of Soda for Rowen.

Plots.	Fertilizers used (Rates per Acre).	Yield (Pounds).	Increase per Acre (Pounds).
Plot 1,	Slag meal, 400 pounds,	1,535	-
Plot 2,	Slag meal, 400 pounds; nitrate of soda, 150 pounds,	2,590	1,074
Plot 3,	Slag meal, 400 pounds,	1,496	-
Plot 4,	Slag meal, 400 pounds; nitrate of soda, 150 pounds,	2,148	592
Plot 5,	Slag meal, 400 pounds,	1,615	-
Plot 6,	Slag meal, 400 pounds; nitrate of soda, 200 pounds,	2,648	1,027
Plot 7,	Slag meal, 400 pounds,	1,627	-
Plot 8,	Slag meal, 400 pounds; nitrate of soda, 250 pounds,	3,614	1,987

The nitrate of soda has in every instance given a considerable increase, — more than enough in every instance to cover the cost of the nitrate applied. As was pointed out last year, however, it is not believed that the large increase on plot 8 is altogether due to the nitrate used, for evidently the moisture conditions on this plot are rather better than on plot 7, with which it is compared. Of the six trials of nitrate of soda for rowen which have been completed, three have shown increases sufficiently large to make the application profitable, while in the other trials the application was made at a loss. As is natural, the result of an application of nitrate for rowen varies widely with the season. When such an application is followed by a sufficient and well-distributed rainfall, it gives a very profitable increase in the crop; but when the weather succeeding the application is dry, the nitrate is relatively non-effective. It is of course impossible to foresee the nature of the weather which will follow the use of nitrate. It would appear, however, that there is at least an equal chance that a moderate application will give a good margin of profit. Close observation of the field in which this experiment has been tried indicates that where, owing to succeeding relatively dry weather, the nitrate proves ineffective for the immediately succeeding crop of rowen, it will, nevertheless, on this fairly compact loam be retained by the soil in sufficient quantity to favorably influence the hay crop of the following season. We have as yet, however, no figures that can be presented which demonstrate this fact.

XI. — VARIETY TEST, POTATOES.

During the past season we have carried out the second year's trial with twenty-five varieties of potatoes. The seed used in making these trials was all of our own production, and was kept under similar conditions throughout the winter. The soil in which the varieties were planted is a medium loam, which was used for corn in 1905. It received a liberal application of commercial fertilizers. The varieties under trial, the area planted to each, the actual yields for each and the rate per acre are shown in the following table: —

VARIETY.	Area planted (Acres).	YIELD PER PLOT (POUNDS).		YIELD PER ACRE (BUSHELS).	
		Large.	Small.	Large.	Small.
Good as Gold,	.0104	52.00	16.00	83.33	25.64
Early Quebec,	.0104	98.00	5.50	157.05	8.81
Chenango White,	.0104	126.75	7.50	203.13	11.91
Reliance,	.0104	108.75	15.00	174.28	24.04
Early Canada,	.0104	112.50	8.50	180.16	13.62
Great Divide,	.0104	82.50	11.50	132.21	18.43
Beauty of Hebron,	.0104	100.00	16.25	160.26	26.04
Clark's Pride,	.0104	84.50	18.00	135.32	28.85
Extra Early White Rose,	.0104	105.50	7.25	169.07	11.62
Banner,	.0104	66.75	2.00	106.97	3.21
Early Rose,	.0104	106.00	14.50	169.87	23.24
Vermont Gold Coin,	.0104	99.25	11.25	159.06	18.03
Climax,	.0104	127.00	17.00	203.52	27.24
Short Seasons,	.0104	59.25	5.00	94.95	8.01
Gorthsap,	.0104	119.00	11.75	190.71	18.83
Dewey,	.0052	59.50	4.00	190.70	12.84
Hammond's Wonderful,	.0052	63.25	6.00	202.72	19.26
Salzer's Sunlight,	.0052	35.50	5.00	113.78	16.01
Keller,	.0052	36.50	1.50	116.99	4.81
Uncle Gideon's Quick Lunch,	.0052	20.75	10.50	66.51	33.65
Noroton Beauty,	.0052	30.75	5.00	98.56	16.01
Nebraska,	.0052	48.00	4.25	153.85	13.62
Simmon's Model,	.0052	63.50	5.50	201.92	17.62
Harris' Snowball,	.0026	18.00	2.00	115.38	12.82
Mills' New Rose Beauty,	.0026	17.25	3.25	110.58	20.83

It will be seen that most of the varieties gave a fairly satisfactory yield. Four only gave a yield of merchantable tubers in excess of 200 bushels; these, in the order of their rank, were: Climax, Chenango White, Hammond's Wonderful and Simmon's Model. Four varieties gave a yield at the rate of less than 100 bushels of merchantable tubers per acre; these, in the order of their inferiority, were: Uncle Gideon's Quick Lunch, Good as Gold, Short Seasons and Noroton Beauty.

The seed of all the varieties was treated with formalin, and the product was free from scab. They were twice sprayed with Bordeaux mixture. The varieties showing blight earliest were Good as Gold, Uncle Gideon's Quick Lunch and Noroton Beauty. All the vines of these varieties were dead on August 14, on which date Salzer's Sunlight, Climax and Clark's Pride were beginning to show blight. The six varieties named were the only ones apparently much affected. Among these varieties, all except Climax gave a small yield, those earliest blighted being among the very poorest.

XII. — Poultry Experiments.

The poultry work of the past year has been a repetition of the feeding experiments of the preceding year. These experiments had indicated: first, that, provided fat is abundant in the ration, high protein content is not essential; second, that, if the fat content of the ration is low, a large proportion of protein in the feeds used appears to be much more essential; and third, that a large proportion of fiber in the ration used is unfavorable to a good egg product. The fowls used in the experiment this year, as last, were pullets of our own raising; and in comparing different food combinations, carefully matched flocks have been kept, as in former years, each in a house by itself, all the houses being of precisely similar dimensions and construction.

1. The fowls in houses Nos. 1 and 2 have been fed on rations characterized by high content both of ash and fat and low fiber. As wheat is relatively deficient in fat, the ration in which it is largely used received an addition of

corn oil. This is mixed with the grains in the mash in such quantities that the total amount of fat in the two food combinations under comparison is substantially the same for each. This experiment, therefore, in a general way affords opportunity to test the relative value for egg production of a ration relatively high in protein (the one containing a large proportion of wheat) with one relatively low in protein (containing a large proportion of corn). The nutritive ratio of the ration used in house No. 1, which may be denominated "the wheat ration," is narrow, — 1 to 4.57. The ration used in house No. 2, which may be called "the corn ration," has a relatively wide nutritive ratio, — 1 to about 6.5. The animal food used in both these rations was beef scraps. The following results were obtained. For the first period, January 25 to April 28, inclusive, the wheat ration produced eggs at the average rate of .48 per hen day; the corn ration, at the rate of .54 per hen day. For the second period, April 28 to September 5, inclusive, the wheat ration produced eggs at the average rate of .37 per hen day; the corn ration, at the rate of .39. In other words, 100 hens, if laying at the same rates, would have produced during the winter period 48 eggs per day on the wheat ration and 54 eggs per day on the corn ration; during the summer period, 37 eggs per day on the wheat ration and 39 eggs per day on the corn ration. The average food cost per egg produced was: for the wheat ration .96 cents, and for the corn ration .73 cents, for the first period; while for the second period the food cost per egg on the wheat ration was 1.01 cents and on the corn ration .82 cents. The gross cost of the food on the wheat ration varied from about .37 cents to .42 cents per day for each fowl, while on the corn ration the cost varied from .31 cents to .36 cents per day. The number of eggs on the corn ration, as will have been noted, was considerably more than on the other. The cost per egg was smaller and the daily cost per fowl was smaller. The results of the past year are in exact accord with those obtained in similar experiments in earlier years. Our egg production with these pens of fowls must be regarded as fairly satisfactory, and it seems impossible to doubt that corn judiciously used in combination with other foods has superior merits for egg production as compared with wheat.

2. The rations fed to the fowls in houses Nos. 3 and 4 were relatively high in ash and low in fiber. Milk albumen was the animal food used. This was selected on account of the low percentage of fat it contains, and the rations fed to the fowls in both of these houses were characterized by much lower fat contents than the rations fed to the fowls in houses Nos. 1 and 2. As in the experiment previously described, the fat content of the two rations used in houses Nos. 3 and 4 was equalized by the addition of corn oil to the one naturally lower in fat. Wheat was the leading grain in the ration fed to the fowls in house No. 3; corn the leading whole grain fed in the other house, No. 4. The results with the fowls in these houses, like the results obtained in houses Nos. 1 and 2, afford a basis for estimating the relative value of wheat and corn, but with a relatively low percentage of fat in both. The nutritive ratios used in this experiment were, for the ration containing wheat, 1 to 4.54; for the ration containing corn, 1 to 6.28. The egg product in this experiment was as follows: for the first period, January 25 to April 28, inclusive, for the wheat ration .49 and for the corn ration .47 eggs per hen day; for the summer period, April 28 to September 5, inclusive, for the wheat ration .35 and for the corn ration .46 eggs per hen day. In other words, 100 fowls, laying at similar rates, would have produced on the wheat ration 49 eggs per day during the winter period and 35 eggs per day during the summer period. On the corn ration, the same number of fowls would have laid 47 eggs per day during the winter period and 46 eggs per day during the summer period. It will be noticed that the result in the winter experiment is favorable to the ration containing the wheat. In the summer, on the other hand, it is favorable to the ration containing the corn. In the experiments reported last year the numbers of eggs both in the winter and in the summer period were greater on the wheat ration, although the cost per egg was less on the corn than on the wheat. In the experiments of the past year the gross cost of food per egg produced on the wheat ration has been

.96 cents both for the winter and summer periods. The gross cost of food per egg on the corn ration for the winter period was .86 cents and for the summer period .74 cents. This year, as last, therefore, the food cost per egg has been less on the corn than on the wheat. It is not easy to understand why the results as measured by the number of eggs produced in one instance should have been favorable to the wheat and in the other to the corn, but it may be that the difference in the average temperature of the two seasons in part accounts for it. It will be remembered that both rations in this experiment are low in fat. One of the products of protein metabolism in the animal body is fat, and fat, as is well understood, is the most effective heat producer. The higher protein content of the ration containing the more wheat may have proved serviceable, therefore, in enabling the fowls the better to maintain normal body temperatures during the cool weather. True, it is generally asserted that corn may be used more freely as a food for laying fowls in winter than in summer. It will be remembered, however, that in this experiment the fat content of the wheat ration was made equal to that of the corn ration by the addition of corn oil. It would seem, therefore, that, while the results in the two periods this year are not in exact agreement, they nevertheless in a general way support the conclusion which has previously been tentatively suggested, viz.: that, unless the fat content of the ration is relatively high, the more starchy foods are not sufficient to produce a satisfactory egg yield, and the product falls below that obtained from feeding a ration higher in protein.

3. The fowls in houses Nos. 5 and 6 received rations in both cases characterized by low protein, high ash and high fat content. The deficiency in fat in the grains selected was made up by the use of corn oil mixed with the meals used in the mash, as in the other experiments. The fowls in house No. 5 were fed grains, including oats and oat feed, characterized by a high proportion of fiber. Those in house No. 6 were fed grains among which rice, which is characterized by a very low percentage of fiber, was prominent. The object in this experiment was to get light regarding the influence

of fiber in the ration on egg production. The nutritive ratio in the two houses was kept substantially the same, about 1 to 6.5. The animal food used in these houses was beef scraps. The results were as follows: For the winter period, January 25 to April 28, inclusive, the egg production was: for the oat ration (high fiber), .32 per hen day; for the rice ration (low fiber), .46. For the summer period, April 28 to September 5, inclusive, the egg production was: for the oat ration (high fiber), .32; and for the rice ration (low fiber), .37 per hen day. In other words, 100 fowls, laying at the same rates, would have produced daily during the winter period, on the oat ration, 32 eggs; on the rice ration, 46 eggs; during the summer period, on the oat ration, 32 eggs; on the rice ration, 37 eggs. The food cost of the eggs was greater on the rice ration than on the oat ration. As has been pointed out in earlier reports, rice, on account of its high price, cannot as a rule be economically used as a food for laying fowls. It is used in this experiment because of its exceptionally low fiber content. The results of the past year are in exact accord with all earlier experiments testing this point. A large proportion of fiber in a ration for laying fowls seems to be highly unfavorable to a satisfactory egg product.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.
Assistants: HENRI D. HASKINS, EDWARD G. PROULX, E. T. LADD.

PART I. — Report on Official Inspection of Commercial Fertilizers.
PART II. — Report on General Work in the Chemical Laboratory.

PART I. — REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS DURING THE SEASON OF 1906.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 64; of these, 40 have offices for the general distribution of their goods in Massachusetts, 11 in New York, 8 in Connecticut, 3 in Vermont, 2 in Ohio, 1 in Rhode Island, 1 in Maryland, 1 in Tennessee, 1 in Arkansas, 1 in Missouri, 1 in Canada, 1 in New Jersey and 1 in Pennsylvania.

Three hundred and fifty-four brands of fertilizers and chemicals have been licensed in Massachusetts during the year. Five hundred and thirty-three samples of fertilizers have been collected up to December 10 in our general markets by an experienced assistant in this department.

Four hundred and ninety-seven samples of officially collected fertilizers have been analyzed at the present date (December 10), representing 323 distinct brands of fertilizers. Some of these analyses were published in our July bulletin No. 111; the others will be published in our January bulletin. The analyses of other officially collected samples of fertilizers, not included in these two publications, will be published in our March bulletin for 1907. Twenty-eight more brands of fertilizers were licensed in Massachusetts during the year than in 1905, and 10 more have been analyzed than during the past year.

The following table shows the general character of the fertilizers analyzed during 1906, as compared with the previous year: —

	1905.	1906.
(*a*) Where three essential elements of plant food were guaranteed (complete fertilizers): —		
Number with three elements equal to or above the highest guarantee,	11	9
Number with two elements above the highest guarantee, . . .	15	22
Number with one element above the highest guarantee, ...	59	71
Number with three elements between the highest and lowest guarantee,	100	106
Number with two elements between the highest and lowest guarantee,	74	71
Number with one element between the highest and lowest guarantee,	24	41
Number with three elements below the lowest guarantee, . . .	1	0
Number with two elements below the lowest guarantee, . . .	14	14
Number with one element below the lowest guarantee, ...	48	45
(*b*) Where two essential elements of plant food were guaranteed (bones, tankage, fish and ashes): —		
Number with two elements above the highest guarantee, . . .	5	3
Number with one element above the highest guarantee, ...	22	20
Number with two elements between the lowest and highest guarantee,	12	7
Number with one element between the lowest and highest guarantee,	14	18
Number with two elements below the lowest guarantee, . . .	2	4
Number with one element below the lowest guarantee, ...	13	8
(*c*) Where one essential element of plant food was guaranteed (chemicals): —		
Number above the highest guarantee, ...	11	13
Number between the lowest and highest guarantee, ...	13	18
Number below the lowest guarantee, ...	10	13

The quality of the officially collected fertilizers for 1906, as shown by the above table, shows a gain over the previous year.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1905 and 1906 (Cents per Pound).

	1905.	1906.
Nitrogen in ammonia salts,	17.50	17.50
Nitrogen in nitrates,	17.00	16.50
Organic nitrogen in dry and fine ground fish, meat, blood, and in high-grade mixed fertilizers,	18.50	18.50
Organic nitrogen in fine bone and tankage,	18.00	18.00
Organic nitrogen in coarse bone and tankage,	13.00	13.00
Phosphoric acid soluble in water,	4.50	4.50
Phosphoric acid soluble in ammonium citrate,	4.00	4.00
Phosphoric acid in fine-ground fish, bone and tankage,	4.00	4.00
Phosphoric acid in cotton-seed meal, castor pomace and wood ashes,	4.00	4.00
Phosphoric acid in coarse fish, bone and tankage,	3.00	3.00
Phosphoric acid insoluble (in water and neutral citrate of ammonia) in mixed fertilizers,	2.00	2.00
Potash as sulphate (free from chlorides),	5.00	5.00
Potash as muriate (chloride),	4.25	4.25
Potash as carbonate,	8.00	8.00

A comparison of the market cost of the various forms in which the three essential elements of plant food are found shows the nitrogen in the form of nitrates to be a half-cent lower in cost than for the previous year; the cost of the other forms of nitrogen, as well as the various sources of potash and phosphoric acid, remains the same as for 1905.

The above schedule of trade values was adopted by representatives of the Massachusetts, Connecticut, Rhode Island, Maine, Vermont and New Jersey experiment stations, at a conference held during the month of February, 1906, and is based upon the condition of the fertilizer market in centers of distribution in New England, New York and New Jersey during the six months preceding March, 1906, and refers to the current market prices, in ton lots, of the leading standard raw materials which furnish nitrogen, phosphoric acid and potash, and which enter largely into the manufacture of our commercial fertilizers.

Table A, on a following page, gives the average composition of licensed commercial fertilizers for 1906.

Table B gives a compilation of analyses of the so-called special crop fertilizers, and shows the wide variation in the chemical composition of this class of goods, the variation in some cases amounting to 10 or 12 per cent. in some one element of plant food which is recommended and used by different manufacturers in compounding a fertilizer for some special crop. This is proof positive that the purchaser of commercial fertilizers must have some more reliable method of selecting his fertilizers than by using the manufacturers' trade names, which, being so contradictory, confuse rather than aid the intelligent buyer. No infallible rule can be laid down in selecting a fertilizer, as so much depends upon the method of crop rotation, the kind of farming in practice, and general soil conditions and requirements. The user of commercial fertilizers will, however, make no mistake in selecting a *high-grade* fertilizer; but whether to select a fertilizer containing a high percentage of some one element of plant food, and how to be guided in this matter, must rest with the individual consumer. The plant food requirements of different soils, as well as different crops, vary widely; and the farmer must discover what particular fertilizing element or elements will most benefit his soil, and select his fertilizer accordingly.

TABLE A. — *Average Analysis of Officially Collected Fertilizers for 1906 (Per Cent.).*

NATURE OF MATERIAL.	Moisture.	NITROGEN IN ONE HUNDRED POUNDS.		PHOSPHORIC ACID IN ONE HUNDRED POUNDS.							POTASSIUM OXIDE IN ONE HUNDRED POUNDS.	
							TOTAL.		AVAILABLE.			
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
General fertilizer,	10.18	3.14	2.71	4.18	3.42	2.91	10.51	8.91	7.60	7.30	5.30	5.05
Ground bone,	6.80	2.98	2.56	–	8.54	16.33	24.87	22.38	8.54	7.81	–	–
Tankage,	9.72	5.39	5.19	–	6.15	10.19	16.34	14.73	6.15	–	–	–
Dry ground fish,	8.26	8.14	8.24	–	3.86	3.95	7.82	6.80	3.86	–	–	–
Basic slag,	–	–	–	–	6.72	12.27	18.99	18.00	6.72	–	–	–
Dissolved bone black,	12.11	–	–	10.77	4.92	1.21	17.01	16.00	15.70	15.00	–	–
Dissolved bone,	6.61	2.46	1.65	5.60	8.42	3.08	17.10	14.00	14.02	12.00	–	–
Acid phosphate,	12.62	–	–	10.85	3.97	1.52	16.34	11.66	14.82	13.00	–	–
Wood ashes,	13.96	–	–	–	–	–	1.33	1.12	–	–	5.77	4.80
Nitrate of soda,	1.76	15.57	15.42	–	–	–	–	–	–	–	–	–
Sulfate of ammonia,	.76	20.78	19.00	–	–	–	–	–	–	–	–	–
Dried blood,	7.55	9.30	9.50	–	–	–	–	–	–	–	–	–
Cotton-seed meal,	6.91	6.69	6.46	–	–	–	–	–	–	–	–	–
Cleveland flax meal,	9.52	6 00	5.76	–	–	–	–	–	–	–	–	–
Chincha Peruvian guano,	10.65	7.33	7.06	2.49	4.80	2.72	10.01	8.50	7.29	6.50	1.88	2.00
Lobos Peruvian guano,	10.40	3.41	3.15	2.78	5.75	9.04	17.57	19.00	8.53	10.00	3.90	3.30
Carbonate of potash,	None.	–	–	–	–	–	–	–	–	–	67.10	67.00
Sulfate of potash,	.84	–	–	–	–	–	–	–	–	–	49.34	48.25
Muriate of potash,	1.36	–	–	–	–	–	–	–	–	–	50.42	50.00
Sulfate of potash-magnesia,	3.95	–	–	–	–	–	–	–	–	–	25.92	26.00
Kainit,	2.07	–	–	–	–	–	–	–	–	–	12.84	12.00

TABLE B. — *Compilation of Analysis of Officially Collected Fertilizers for 1906, Special Crop Brands (Per Cent.).*

NAME OF FERTILIZER.	Moisture.	NITROGEN IN ONE HUNDRED POUNDS.			TOTAL PHOSPHORIC ACID IN ONE HUNDRED POUNDS.			AVAILABLE PHOSPHORIC ACID IN ONE HUNDRED POUNDS.			POTASSIUM OXIDE IN ONE HUNDRED POUNDS.		
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
Corn fertilizer,	10.77	4.16	1.61	2.61	16.64	9.22	11.55	9.66	5.12	8.39	10.94	1.80	4.00
Fruit and vine,	9.77	2.78	2.50	2.64	13.86	7.24	10.55	10.84	3.78	7.31	11.42	3.32	7.37
Grass fertilizer,	7.89	5.69	3.10	4.27	14.32	4.84	9.17	10.98	2.78	6.38	8.30	2.06	5.28
Market garden fertilizer,	9.77	4.68	2.03	3.19	14.00	7.16	10.65	10.08	5.76	7.63	12.08	2.06	6.67
Onion fertilizer,	10.72	4.31	3.62	3.88	12.10	7.88	10.18	9.98	6.50	7.80	7.98	6.28	6.95
Potato fertilizer,	10.80	5.62	1.32	2.81	15.46	6.70	10.61	9.72	4.16	7.68	10.14	3.10	6.09
Root crop fertilizer,	10.56	3.66	2.75	3.28	11.90	9.86	10.89	8.90	7.26	8.22	7.66	6.50	7.23
Tobacco fertilizer,	8.56	8.56	1.09	4.42	15.08	4.24	8.06	9.14	2.40	5.85	15.88	2.62	6.40

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State during the Past Year (May 1, 1906, to May 1, 1907), and the Brands licensed by Each.

The American Agricultural Chemical Co., Boston, Mass.: —
- High-grade Fertilizer with Ten Per Cent. Potash.
- Grass and Lawn Top-dressing.
- Tobacco Starter and Grower.
- Fine-ground Bone.
- Dissolved Bone Black.
- Muriate of Potash.
- Double Manure Salt.
- High-grade Sulfate of Potash.
- Nitrate of Soda.
- Dry Ground Fish.
- Plain Superphosphate.
- Sulfate of Ammonia.
- Kainit.
- Dried Blood.
- Fine-ground Tankage.
- Ground South Carolina Phosphate.
- High-grade Tobacco Manure.

The American Agricultural Chemical Co. (Bradley Fertilizer Co., branch), Boston, Mass.: —
- Bradley's Complete for Potatoes and Vegetables.
- Bradley's Complete for Corn and Grain.
- Bradley's Complete Manure with Ten Per Cent. Potash.
- Bradley's Complete Top-dressing Grass and Grain.
- Bradley's X. L. Superphosphate.
- Bradley's Potato Manure.
- Bradley's Potato Fertilizer.
- Bradley's Corn Phosphate.
- Bradley's Eclipse Phosphate.
- Bradley's Niagara Phosphate.
- Bradley's English Lawn Fertilizer.
- Bradley's Columbia Fish and Potash.
- Bradley's Abattoir Bone Dust.
- Bradley's Seeding-down Manure.
- Church's Fish and Potash.

The American Agricultural Chemical Co. (H. J. Baker & Bro., branch), New York, N. Y.: —
- Baker's A. A. Ammoniated Superphosphate.
- Baker's Complete Potato Manure.

The American Agricultural Chemical Co. (Clark's Cove Fertilizer Co., branch), Boston, Mass.: —
- Clark's Cove Bay State Fertilizer.
- Clark's Cove Bay State Fertilizer G. G.

The American Agricultural Chemical Co. (Clark's Cove Fertilizer Co., branch), Boston, Mass. — *Con.*
- Clark's Cove Great Planet Manure.
- Clark's Cove Potato Manure.
- Clark's Cove Potato Fertilizer.
- Clark's Cove King Philip Guano.

The American Agricultural Chemical Co. (Crocker Fertilizer and Chemical Co., branch), Buffalo, N. Y.: —
- Crocker's Potato, Hop and Tobacco Phosphate.
- Crocker's Corn Phosphate.
- Crocker's A. A. Complete Manure.

The American Agricultural Co. (Cumberland Bone Phosphate Co., branch), Boston, Mass.: —
- Cumberland Superphosphate.
- Cumberland Potato Fertilizer.

The American Agricultural Chemical Co. (L. B. Darling Fertilizer Co., branch), Pawtucket, R. I.: —
- Darling's Blood, Bone and Potash.
- Darling's Complete Ten Per Cent. Manure.
- Darling's Potato Manure.
- Darling's Farm Favorite.
- Darling's Potato and Root Crop Manure.
- Darling's General Fertilizer.

The American Agricultural Chemical Co. (Great Eastern Fertilizer Co., branch), Rutland, Vt.: —
- Great Eastern Northern Corn Special.
- Great Eastern Vegetable Vine and Tobacco.
- Great Eastern Garden Special.
- Great Eastern General.
- Great Eastern Grass and Oats Fertilizer.

The American Agricultural Chemical Co. (Pacific Guano Co., branch), Boston, Mass.: —
- Pacific High-grade General.
- Pacific Potato Special.
- Soluble Pacific Guano.
- Pacific Nobsque Guano.

The American Agricultural Chemical Co. (Packers' Union Fertilizer Co., branch), Rutland, Vt.: —
- Packers' Union Gardeners' Complete Manure.
- Packers' Union Animal Corn Fertilizer.
- Packers' Union Potato Manure.
- Packers' Union Universal Fertilizer.
- Packers' Union Wheat, Oats and Clover Fertilizer.

The American Agricultural Chemical Co. (Quinnipiac Co., branch), Boston, Mass.: —
- Quinnipiac Market-garden Manure.
- Quinnipiac Phosphate.
- Quinnipiac Potato Manure.
- Quinnipiac Potato Phosphate.
- Quinnipiac Corn Manure.
- Quinnipiac Climax Phosphate.
- Quinnipiac Onion Manure.

The American Agricultural Chemical Co. (Read Fertilizer Co., branch), New York, N. Y.: —
- Read's Practical Potato Special.
- Read's Farmer's Friend.
- Read's Standard.
- Read's High-grade Farmer's Friend.
- Read's Vegetable and Vine.

The American Agricultural Chemical Co. (Standard Fertilizer Co., branch), Boston, Mass.: —
- Standard Complete Manure.
- Standard Fertilizer.
- Standard Special for Potatoes.
- Standard Guano.

The American Agricultural Chemical Co. (Henry F. Tucker Co., branch), Boston, Mass.: —
- Tucker's Original Bay State Bone Superphosphate.
- Tucker's Special Potato.

The American Agricultural Chemical Co. (Williams & Clark Fertilizer Co., branch), Boston, Mass.: —
- Williams & Clark's High-grade Special.
- Williams & Clark's Americus Phosphate.
- Williams & Clark's Potato Phosphate.
- Williams & Clark's Potato Manure.
- Williams & Clark's Corn Phosphate.
- Williams & Clark's Royal Bone Phosphate.
- Williams & Clark's Prolific Crop Producer.

The American Agricultural Chemical Co. (M. E. Wheeler & Co., branch), Rutland, Vt.: —
- Wheeler's Corn Fertilizer.
- Wheeler's Potato Manure.
- Wheeler's Havana Tobacco Grower.
- Wheeler's Bermuda Onion Grower.
- Wheeler's Grass and Oats Fertilizer.

W. H. Abbott, Holyoke, Mass.: —
- Abbott's Tobacco Fertilizer.
- Abbott's Onion Fertilizer.
- Abbott's Animal Fertilizer.
- Abbott's Eagle Brand Fertilizer.

The American Cotton Oil Co., New York City: —
- Cotton-seed Meal.
- Cotton-hull Ashes.

The American Linseed Co., New York, N. Y.: —
- Cleveland Flax Meal.

The Armour Fertilizer Works, Baltimore, Md.: —
- Fruit and Root Fertilizer.
- Blood, Bone and Potash.
- High-grade Potato.
- All Soluble.
- Ammoniated Bone with Potash.
- Bone Meal.
- Complete Potato.
- Corn King.
- Market Garden.
- Grain Grower.

H. J. Baker & Bro., New York, N. Y.: —
- Castor Pomace.

Beach Soap Co., Lawrence, Mass.: —
- Beach's Advance Brand.
- Beach's Reliance Brand.

Berkshire Fertilizer Co., Bridgeport, Conn.: —
- Berkshire Complete Fertilizer.
- Berkshire Potato and Vegetable Phosphate.
- Berkshire Ammoniated Bone Phosphate.
- Berkshire Grass Fertilizer.

Joseph Breck & Sons, Boston, Mass.: —
- Breck's Lawn and Garden Dressing.
- Breck's Market-garden Manure.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures.
- Bowker's Hill and Drill Phosphate.
- Bowker's Farm and Garden Phosphate.

Bowker Fertilizer Co., Boston, Mass. — *Con.*
- Bowker's Lawn and Garden Dressing.
- Bowker's Potato and Vegetable Fertilizer.
- Bowker's Fish and Potash (Square Brand).
- Bowker's Potato and Vegetable Phosphate.
- Bowker's Sure Crop Phosphate.
- Gloucester Fish and Potash.
- Bowker's High-grade Fertilizer.
- Bowker's Bone and Wood Ash Fertilizer.
- Bowker's Fish and Potash ("D" Brand).
- Bowker's Corn Phosphate.
- Bowker's Bone, Blood and Potash.
- Bowker's Early Potato Manure.
- Bristol Fish and Potash.
- Bowker's Fine-ground Fish.
- Bowker's Tobacco Ash Elements.
- Bowker's Wood Ashes.
- Bowker's Ground Bone.
- Bowker's Superphosphate.
- Bowker's Sulfate of Ammonia.
- Bowker's Nitrate of Soda.
- Bowker's Dissolved Bone Black.
- Bowker's Kainit.
- Bowker's Muriate of Potash.
- Bowker's Sulfate of Potash.
- Dried Blood.
- Bowker's Soluble Animal Fertilizer.
- Bowker's Tobacco Starter.
- Bowker's Tobacco Ash Fertilizer.
- Bowker's Market-garden Fertilizer.
- Bowker's Potash Bone.
- Bowker's Ten Per Cent. Manure.
- Bowker's Complete Mixture.
- Bowker's Ammoniated Food for Flowers.
- Bowker's Double Manure Salt.
- Bowker's Tankage.
- Bowker's Clover Brand Bone and Wood Ash Fertilizer.
- Bowker's Flour of Bone.
- Bowker's Market Bone.
- Bowker's Ground Phosphate Rock.
- Bowker's Ammoniated Dissolved Bone.
- Bowker's Square Brand Bone and Potash.
- Bowker's Potash or Staple Phosphate.
- Bowker's Special Fertilizer for Seeding Down.

F. W. Brode & Co., Memphis, Tenn.: —
- Owl Brand Cotton-seed Meal.

T. H. Bunch Co., Little Rock, Ark.: —
- Cotton-seed Meal.

The Buffalo Fertilizer Co., Buffalo, N. Y.: —
- Fish Guano.
- Farmer's Choice.
- York State Special.
- Vegetable and Potato.
- Garden Truck.
- High-grade Manure.

Charles M. Cox Co., Boston, Mass.: —
- Cotton-seed Meal.

Chicopee Rendering Co., Springfield, Mass.: —
- Farquhar's Lawn and Garden Dressing.
- Farquhar's Vegetable and Potato Fertilizer.

The Coe-Mortimer Co., New York, N. Y.: —
- New Englander Corn and Potato Fertilizer.
- Columbian Corn and Potato Fertilizer.
- Basic Slag.
- Excelsior Potato Fertilizer.
- Gold Brand Excelsior Guano.
- X X X Ammoniated Bone Phosphate.
- Nitrate of Soda.
- Celebrated Special Potato.
- High-grade Ammoniated Bone Superphosphate.
- Chincha Peruvian Guano.
- Lobos Peruvian Guano.

John C. Dow & Co., Boston, Mass.: —
- Dow's Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
- Imperial Plant Food.

R. & J. Farquhar & Co., Boston, Mass.: —
- Canada Unleached Hard-wood Ashes.
- Clay's London Fertilizer.

Fyfe, Fay & Plummer, Clinton, Mass.: —
- Hard-wood Canada Ashes.

C. B. Hastings, Ashmont, Mass.: —
- Ferti Flora.

Thomas Hersom & Co., New Bedford, Mass.: —
- Meat and Bone.
- Bone Meal.

The Home Soap Co., Worcester, Mass.: —
Ground Bone.

Hunter Brothers Milling Co., St. Louis, Mo.: —
Cotton-seed Meal.

John Joynt, Lucknow, Ontario, Can.: —
Unleached Hard-wood Ashes.

A. Klipstein & Co., New York, N. Y.: —
Carbonate of Potash.

Lister's Agricultural Chemical Works, Newark, N. J.: —
Lister's High-grade Special.
Lister's Success.
Lister's Special Corn.
Lister's Special Potato.
Lister's Potato Manure.
Lister's Oneida Special.
Lister's Bone and Potash.

Stephen Major, South Somerset, Mass.: —
Major's Bone Phosphate No. 1.

Edward MacMulkin, Boston, Mass.: —
Ideal Plant Food.

Swift's Lowell Fertilizer Co., Boston, Mass.: —
Swift's Lowell Bone Fertilizer.
Swift's Lowell Potato Phosphate.
Swift's Lowell Dissolved Bone and Potash.
Swift's Lowell Animal Brand.
Swift's Lowell Market-garden Manure.
Swift's Lowell Potato Manure.
Swift's Lowell Empress Brand.
Swift's Lowell Superior Fertilizer.
Swift's Lowell Special Grass Mixture.
Swift's Lowell Lawn Dressing.
Swift's Lowell Perfect Tobacco Grower.
Swift's Lowell Ground Bone.
Acid Phosphate.
Nitrate of Soda.
Muriate of Potash.
Tankage.
Dried Blood.
High-grade Sulfate of Potash.
Dissolved Bone Black.
Swift's Lowell Special Vegetable Fertilizer.

George E. Marsh & Co., Lynn, Mass.: —
Bone Meal.

Mapes Formula & Peruvian Guano Co., New York, N. Y.: —
Mapes' Grass and Grain Spring Top-dressing.
Mapes' Complete Manure for General Use.
Mapes' Fruit and Vine Manure.
Mapes' Cereal Brand.
Mapes' Lawn Top-dressing.
Mapes' Cauliflower and Cabbage Manure.
Mapes' Potato Manure.
Mapes' Tobacco Starter Improved.
Mapes' Tobacco Manure (Wrapper Brand).
Mapes' Economical Potato Manure.
Mapes' Average Soil Complete Manure.
Mapes' Vegetable Manure or Complete Manure for Light Soils.
Mapes' Corn Manure.
Mapes' Complete Manure ("A" Brand).
Mapes' Complete Manure Ten Per Cent. Potash.
Mapes' Top-dressing Improved, Half Strength.
Mapes' Tobacco Ash Constituents.

George L. Monroe & Sons, Oswego, N. Y.: —
Pure Canada Unleached Wood Ashes.

D. M. Moulton, Monson, Mass.: —
Ground Bone.

W. H. Nash, Boston, Mass.: —
Lime-Kiln Ashes.

National Fertilizer Co., Bridgeport, Conn.: —
Chittenden's Ammoniated Bone.
Chittenden's Universal.
Chittenden's Potato Phosphate.
Chittenden's Complete.
Chittenden's Fish and Potash.
Chittenden's Tobacco Starter.
Chittenden's Tobacco Grower.
Chittenden's Market Garden.
Chittenden's Tobacco Special.
Chittenden's Complete Tobacco.
Chittenden's High-grade Special Tobacco.

New England Fertilizer Co., Boston, Mass.: —
New England Corn Phosphate.
New England Potato Fertilizer.
New England Superphosphate.
New England High-grade Potato Fertilizer.

Olds & Whipple, Hartford, Conn.: —
- Complete Tobacco Fertilizer.
- Home Mixture for Onions.
- Vegetable Potash.
- Corn and Potato Fertilizer.
- Cotton-seed Meal.

R. T. Prentiss, Holyoke, Mass.: —
- Complete Fertilizers.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
- Plymouth Rock Brand.
- Strawberry Special.
- Special Potato.
- A. A. Brand.
- P. & P. Potato.
- Lawn Dressing.
- P. & P. Grain Grower.
- Star Brand.
- Pure Ground Bone.
- Nitrate of Soda.
- Aroostook Special.

Rogers & Hubbard Co., Middletown, Conn.: —
- Hubbard's Complete Phosphate.
- Hubbard's Grass and Grain Fertilizer.
- Hubbard's Market-garden Phosphate.
- Hubbard's Oats and Top-dressing.
- Hubbard's Potato Phosphate.
- Hubbard's Soluble Corn and General Crops.
- Hubbard's Soluble Potato Manure.
- Hubbard's Soluble Tobacco Manure.
- Hubbard's Raw Knuckle Bone Flour.
- Hubbard's Strictly Pure Fine Bone.

Rogers Manufacturing Co., Rockfall, Conn.: —
- All-round Fertilizer.
- Complete Potato and Vegetable Fertilizer.
- High-grade Complete Corn and Onion.
- Fish and Potash.
- High-grade Tobacco and Potato.
- High-grade Oats and Top-dressing.
- High-grade Grass and Grain.
- High-grade Soluble Tobacco.
- Pure Knuckle Bone.

Ross Brothers, Worcester, Mass.: —
- Lawn and Garden Fertilizer.

N. Roy & Son, South Attleborough, Mass.: —
- Potato Fertilizer.
- Complete Animal Fertilizer.

Russia Cement Co., Gloucester, Mass.: —
- Essex Dry Ground Fish.
- Essex Complete for Corn, Grain and Grass.
- Essex Complete for Potatoes, Roots and Vegetables.
- Essex Market-garden and Potato Manure.
- Essex Corn Fertilizer.
- Essex A. 1. Superphosphate.
- Essex X X X Fish and Potash.
- Essex Odorless Lawn Dressing.
- Essex Tobacco Starter.
- Essex Special Tobacco Manure.
- Essex Rhode Island Special for Potatoes.
- Essex Grass and Top-dressing.
- Essex Nitrate of Soda.

The Salisbury Cutlery Handle Co., Salisbury, Conn.: —
- Ground Bone.

Sanderson's Fertilizer & Chemical Co., New Haven, Conn.: —
- Sanderson's Formula "A."
- Sanderson's Formula "B."
- Sanderson's Top-dressing Grass and Grain.
- Sanderson's Potato Manure.
- Sanderson's Atlantic Coast Bone, Fish and Potash.
- Sanderson's Fine-ground Fish.
- Nitrate of Soda.
- High-grade Sulfate of Potash.
- Muriate of Potash.
- Plain Superphosphate.
- Walker's Complete Phosphate.

M. L. Shoemaker & Co., Limited, Philadelphia, Pa.: —
- Swift Sure Superphosphate.
- Swift Sure Bone Meal.

The Smith Agricultural Chemical Co. (Abbott and Martin Rendering Co., branch), Columbus, O.: —
- Harvest King.
- Tobacco and Potato Special.
- Martin's Truck Fertilizer.

The Smith Agricultural Chemical Co. (Hardy Packing Co., branch), Columbus, O.: —
- Tankage, Bone and Potash.
- Tobacco and Potato Special.

Sterling Chemical Co., Cambridgeport, Mass.: —
- Sterlingworth Concentrated Plant Food.

Thomas L. Stetson, Randolph, Mass.: —
- Stetson's Ground Bone.

A. L. Warren, Northborough, Mass.: —
- Warren's Ground Bone.

Whitman & Pratt Rendering Co., Lowell, Mass.: —
- Vegetable Grower.
- All Crops Fertilizer.
- Corn Success.
- Potato Plowman.
- Ground Bone.

Wilcox Fertilizer Works, Mystic, Conn.: —
- Potato, Onion and Vegetable Manure.
- Potato Fertilizer.
- Complete Bone Superphosphate.
- Fish and Potash.
- High-grade Tobacco Special.
- Dry Ground Fish.

Sanford Winter, Brockton, Mass.: —
- Winter's Ground Bone.

J. M. Woodard & Bro., Greenfield, Mass.: —
- Tankage.

PART II. — REPORT ON GENERAL WORK IN THE CHEMICAL LABORATORY.

C. A. GOESSMANN.

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1. Analyses of materials forwarded for examination.
2. Notes on wood ashes and lime ashes.

1. ANALYSES OF MATERIALS FORWARDED FOR EXAMINATION.

During the year 343 samples of miscellaneous substances have been received from farmers within our State. These samples have been analyzed as expeditiously as possible, the samples being taken up, as a rule, in the order of their arrival at this office; although precedence is sometimes given to farmers' clubs, grange organizations and private parties, who depend upon the results of our analysis as a basis for settlement for their fertilizers. We have most time at our disposal for this class of work from the middle of December until the first of April, as during this time we are not engaged in the annual inspection of commercial fertilizers. Whenever practical, it would be well for those who desire a speedy return of results of analyses to take advantage of this fact, and send samples for analysis before the beginning of our inspection season.

During the year we have been in co-operation with the Association of Official Agricultural Chemists, studying new methods of analyses of soils, fertilizers and insecticides. This is a very important part of the practical chemists' work, and time should be taken every year for this co-operative investigation.

The year has seen some new developments along the line of producing valuable agricultural compounds for fertilizing purposes. These developments have naturally inclined towards producing new compounds of our most expensive element of plant food, nitrogen. Statistics show that, at the present rate of consumption, it is only a matter of a few years before the supply of nitrate of soda from our present source will become exhausted. This will become a very serious matter, unless new deposits of nitrate are discovered, or science shows us an economical method of utilizing the inexhaustible supply of atmospheric nitrogen. Attempts have been made to manufacture nitric acid by an electrical method which utilizes the nitrogen of the air, and which has proven more or less successful. Attempts have also been made to combine the atmospheric nitrogen with lime to form cyanimid compounds. This method has also been successful, but whether these cyanimid compounds will prove practical fertilizers or not we are at present unable to say. It has long been known that cyanogen compounds are poisonous to plant growth; but they are easily decomposed, and it is possible that it may be found safe to use them by applying them to the soil some time previous to the planting of the crop.

During the year we have heard much about the use of ground feldspar and granitic rocks as a source of potash. In the early history of the use of artificial fertilizers, potash in the form of silicates was recommended. They were, however, found unsuitable as a source of potash, as they were not easily decomposed, and the more soluble forms of potash soon took their place. It is a well-known fact that many soils of granitic origin are benefited by an application of soluble potash compounds. In view of the above facts, we would caution the user of commercial fertilizers against purchasing ground feldspathic rocks as a source of potash. Through a process of electrolysis and endosmosis, investigators have succeeded in recovering 80 per cent. of the potash in feldspathic rocks. In this age of cheapening electrical power it may not be impossible that this process may be successfully employed to economically produce potash for our future needs in the fertilization of agricultural soils for farm crops.

Following is a partial list of materials forwarded by farmers during the year: —

Soils,	55
Complete fertilizers,	45
Wood ashes,	41
Cotton-seed meal,	28
Nitrate of soda,	13
Peruvian guano,	11
Carbonate of potash,	7
Sulfate of potash,	8
Ground bones,	6
Dry ground fish,	6
Fine-ground tankage,	6
Lime ashes,	6
Paris green,	6
Dried blood,	4
Dissolved bone black,	4
Muriate of potash,	4
Cotton waste,	4
Sheep manure,	4
Lime,	3
Dissolved bone,	3
Sulfate of potash-magnesia,	3
Nitrate of potash,	3
Arsenate of lead,	3
Acid phosphate,	4
Phosphatic slag,	3
Oyster-shell lime,	2
Linseed meal,	2
Muck,	2
Granite,	2
Talc,	2
Cotton-hull ashes,	2
Leather refuse,	2
Glue refuse,	1
Cave deposit,	1
Carbonate of lime,	1
Leather dust,	1
Tobacco stems,	1
Kainit,	1
Pigeon manure,	1
Clay,	1
Bone soup,	1
Peat,	1
Wool washings,	1
Arsenate of soda,	1
London purple,	1
Saltpeter waste,	1
Bone waste,	1
Horn waste,	1
Coal ashes,	1
Sludge from filter beds,	1
Hoof meal,	1
South Carolina rock phosphate,	1
Manure,	1
Sulfate of ammonia,	1
Steamed bone,	1
Manure and lime,	1
Bone scrap,	1
Burned bone,	1
Carbonate of potash-magnesia,	1
Calcium cyanimid,	1
Washings from paper mill,	1
Soft coal soot,	1
Castor pomace,	1
Nitrogenous chalk,	1
Peat and manure,	1
Wool waste,	1
River mud,	1
Woodland leaf mold,	1
Miscellaneous,	12

2. NOTES ON WOOD ASHES AND LIME ASHES.

(*a*) *Wood Ashes.*

Forty-one samples of wood ashes have been forwarded for analysis by farmers during the past year. The majority of these ashes are used by the farmers in the Connecticut valley. The following table shows their chemical composition as compared with 1905: —

Analysis of Wood Ashes.

	NUMBER OF SAMPLES.	
	1905.	**1906.**
Moisture from 1 to 10 per cent.,	15	8
Moisture from 10 to 20 per cent.,	20	19
Moisture from 20 to 30 per cent.,	7	10
Moisture above 30 per cent.,	1	0
Potassium oxide above 7 per cent.,	4	3
Potassium oxide from 6 to 7 per cent.,	4	7
Potassium oxide from 5 to 6 per cent.,	12	6
Potassium oxide from 4 to 5 per cent.,	13	9
Potassium oxide from 3 to 4 per cent.,	7	9
Potassium oxide below 3 per cent.,	3	2
Phosphoric acid above 2 per cent.,	7	1
Phosphoric acid from 1 to 2 per cent.,	32	31
Phosphoric acid below 1 per cent.,	4	6
Average per cent. of calcium oxide,	32.30	28.17
Insoluble matter below 10 per cent.,	9	3
Insoluble matter from 10 to 15 per cent.,	14	16
Insoluble matter above 15 per cent.,	20	18

Table showing Maximum, Minimum and Average Per Cents. of the Different Ingredients found in Wood Ashes, 1905 and 1906.

	MAXIMUM.		MINIMUM.		AVERAGE.	
	1905.	**1906.**	**1905.**	**1906.**	**1905.**	**1906.**
Moisture at 100° C.,	32.65	26.17	.02	.65	13.45	14.78
Potassium oxide,	8.68	7.54	2.32	2.75	5.09	5.02
Phosphoric acid,	4.74	2.90	.38	.44	1.69	1.28
Calcium oxide,	49.24	35.60	21.17	19.28	32.30	28.17
Insoluble matter,	33.32	30.25	4.15	4.04	15.49	16.02

A comparison of the figures in the above tables shows that the ashes analyzed during the season contained, on the average, less potash, phosphoric acid and lime and more water and sand than during the previous year. This emphasizes the importance of buying this class of material on a statement of guarantee of potash, phosphoric acid and lime; also of patronizing those importers who have complied with our State laws, and have secured licenses for the sale of wood ashes in Massachusetts. A list of these importers will be found on a previous page of this report.

(*b*) *Lime Ashes.*

Table showing Maximum, Minimum and Average Per Cents. of the Different Ingredients found in Lime Ashes, 1905 and 1906.

	MAXIMUM.		MINIMUM.		AVERAGE.	
	1905.	**1906.**	**1905.**	**1906.**	**1905.**	**1906.**
Moisture at 100° C.,	19.35	21.65	.05	none.	11.18	5.99
Potassium oxide,	4.80	3.72	1.02	1.44	2.46	2.54
Phosphoric acid,	1.58	1.16	.18	.34	.97	.71
Calcium oxide,	63.44	49.74	37.56	29.33	49.34	40.39
Insoluble matter,	28.93	34.93	3.21	4.04	8.99	9.51

The average composition of lime ashes is about the same as for the previous year.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.

Chemists: E. B. HOLLAND, P. H. SMITH, A. C. WHITTIER,[1] L. S. WALKER.[2]
Inspector of Feeds and Babcock Machines: F. G. HELYAR,[3] W. K. HEPBURN.
Dairy Tester: S. R. PARKER,[4] H. A. PARSONS.
In Charge of Feeding Experiments: R. F. GASKILL.
Clerk and Stenographer: MABEL C. SMITH.

PART I. — OUTLINE OF THE YEAR'S WORK.
- Correspondence.
- Summary of laboratory work.
- Water analysis.
- Dairy products and cattle feeds.
- Special chemical work.
- Execution of feed law.
- Execution of dairy law.
- The testing of pure-bred cows.
- Work completed.
- Work in progress.
- Changes in staff.

PART II. — WORK IN ANIMAL NUTRITION.
- The digestibility of cattle feeds.

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[1] Resigned July 1.
[2] Since July 1.
[3] Resigned October 1.
[4] Resigned June 1.

PART I. — OUTLINE OF THE YEAR'S WORK.

J. B. LINDSEY.

CORRESPONDENCE.

A considerable correspondence is carried on yearly with farmers, grain dealers and other station workers. Numerous questions are asked concerning feeds and methods of feeding. The execution of the dairy and feed law involves the exchange of many letters. Letters of all kinds, sent from Dec. 15, 1905, through Dec. 15, 1906, approximated 3,200.

SUMMARY OF LABORATORY WORK.

From Dec. 15, 1905, to Dec. 15, 1906, there have been received and examined 124 samples of water, 310 of milk, 1,799 of cream, 152 of feed stuffs and 2 miscellaneous. In connection with experiments made by this and other divisions of the station, there have been examined, in whole or in part, 336 samples of milk and cream and 187 of cattle feeds. There have also been collected and examined 703 samples of cattle feeds, in accordance with the requirements of the feed law. The total for the year has been 3,613, as compared with 4,042 in 1905 and 4,261 during 1904. Work with condensed milk, molasses, maple sugar, ash and nitrogen, not included in the above summary, has been carried on for the Association of Official Agricultural Chemists. Twenty-three candidates have been examined and given certificates to operate Babcock machines, and 2,457 pieces of Babcock glassware have been tested for accuracy of graduation.

WATER ANALYSIS.

The station continues to make sanitary analyses of drinking waters, at a charge of $3 each. Special jars are furnished, together with full instructions for collecting and forwarding the samples. An analysis of water sent in shippers' jars will not be made, neither will bacteriological nor mineral analyses be undertaken.

The character of the samples received has been much the same as that of those examined in previous years. They were mostly from wells or springs, which frequently were located in too close proximity to houses, barns and outbuildings, and received the drainage. Samples are often found contaminated with lead; the station can only repeat its warning that all lead pipe be discarded, and replaced with iron coated with asphaltum, or with galvanized-iron pipe.

Dairy Products and Cattle Feeds.

Farmers and dairymen continue to send samples of cream and skim milk to be tested for butter fat, and samples of whole milk to be tested for both solids and fat. More milk is being sold for market purposes than formerly, and less made into butter. The inspection of the quality of milk is more general and rigid from year to year. Dairymen wish to ascertain the composition of milk produced by individual cows and by their herds, and likewise to confirm analyses reported to them by the city milk inspectors and by contractors. This work is performed gratis, and the results reported promptly, together with such remarks and suggestions as special cases call for. One creamery sends all of the cream samples to be tested regularly, and others send occasional lots when not in condition to perform the work. A charge sufficient to cover the cost is made in such cases.

Samples of feeds (mostly concentrates) are received from farmers, as well as from local grain dealers and jobbers. The station willingly examines such material without charge, when it seems that the conditions warrant it, and promptly reports its findings with suggestions when necessary. It must be understood, however, that it cannot become the free chemists of jobbers and manufacturers who wish to have analyses made purely for commercial purposes.

Special Chemical Work.

This division has devoted some time to a study of methods used in chemical analysis, in co-operation with the Association of Official Agricultural Chemists. The work undertaken was as follows: —

1. A comparison of the Kjeldahl, Kjeldahl-Gunning and modified Gunning methods, for the determination of total organic nitrogen.

2. The determination of available organic nitrogen by the neutral permanganate and by the alkaline permanganate methods.

3. A study of the Babcock asbestos, dish and sand, and Gottlieb methods, Babcock centrifugal and Leach and Farrington modifications of the same, for the determination of fat in sweetened and unsweetened condensed milk.

4. Observations in the determination of lactose and sucrose in sweetened and unsweetened condensed milk, by aid of Fehling's solution, the copper being titrated with thiosulfate.

5. Determinations of moisture, ash, protein, dextrose and sucrose in massecuit, sugar and molasses. Considerable time was spent in a special study of different methods for the accurate determination of moisture in molasses, which has not been reported; it will be published when sufficient data have been secured to warrant the making of positive deductions.

6. Determinations of total, soluble and insoluble ash in pure and adulterated maple sugar, as well as the alkalinity of the soluble and insoluble ash.

The results of the above work were presented to the association, and became a part of their yearly report. It was carried out by Messrs. Holland and Smith, to whom due credit should be given.

In addition to the above, work is now in progress in determining the water and starch in 36 samples of potatoes.

EXECUTION OF THE FEED LAW (ACTS OF 1903, CHAPTER 122).

The methods employed in carrying out the provisions of this act have been essentially the same as in former years. The State has been thoroughly canvassed twice, the first time in January, February and March, and the second time in August, September and October. The inspector also spent the larger part of May in the most important grain-consuming portions of the State, and in addition made several short trips. There have been collected and examined during the year 703 samples of cattle and poultry feeds. Bulletin No. 108, containing the analyses of 365 samples collected during the autumn of 1905, was issued in January, 1906. Another bulletin is now being prepared for publication, and will be issued in December or early January. In addition to the regular yearly bulletin, the station sends out many letters to dealers and manufacturers concerning the values of feeds and explanatory of the feed law.

The only really adulterated feeds now on the market consist of mixtures of wheat bran and corn cobs. Such goods are usually properly guaranteed, but it is believed that unscrupulous dealers are inclined to remove the tags before selling, and dispose of them for genuine mixed wheat feeds.

Cotton-seed meal offered in local markets has shown a gradual decline in quality since 1902, while the price per ton has increased steadily since 1898. Gluten meal and germ oil meal are no longer offered. Distillers' dried grains are easily obtainable at reasonable prices. Brewers' dried grains of excellent quality have been placed in Massachusetts markets during the past year.

A number of proprietary grain mixtures or ready grain rations for dairy stock are now on sale, several of which are quite satisfactory; the price asked, however, is in excess of equally desirable mixtures which can be prepared by the dairymen from standard concentrates to be had of all local grain dealers.

Mixtures of corn, together with different amounts of oat residues, often designated stock foods, are widely distributed, and, judging from the number of brands, must find a ready sale. The corn is frequently of poor quality, being imperfectly developed, musty and sour. The price asked is usually in excess of their real value.

The number of brands of poultry foods, such as meat scraps, meat and bone meal, poultry meals and mashes, chick and scratching grains, is increasing from year to year. Poultrymen can prepare equally as desirable mashes or scratching mixtures for 25 cents less per hundred pounds. Full details concerning the great variety of cattle and poultry feeds now for sale in the markets of the State may be found by consulting the special feed bulletins.

Execution of the Dairy Law (Acts of 1901, Chapter 202).

The station has done its best to carry out the provisions of this law, which makes it obligatory for all creameries and milk depots in the State employing the Babcock test, or any other test for determining the value of milk or cream, to have all glassware used in making such determinations tested for accuracy of graduation. The law further requires that all parties intending to operate such machines be examined for competency by the proper station official. The station is also required once each year to send a competent party to each creamery and milk depot within the State where Babcock machines are in use, and pronounce upon their fitness for the work.

(*a*) *Inspection of Glassware.* — Each piece of glassware found to be correctly graduated has the letters "Mass Ex St" etched on. There were examined 2,457 pieces, of which 763, or 31.05 per cent., were condemned. This record shows gross carelessness on the part of some manufacturers.

(*b*) *Examination of Candidates.* — Twenty-three candidates have been examined during 1906. Some were well prepared, while others were refused a certificate on first trial and were obliged to take a second examination. The value of the law requiring the inspection of glassware and the examination of operators is made especially clear by the above records.

(*c*) *Inspection of Babcock Machines.* — The inspection of machines the present year has been in charge of Mr. William K. Hepburn, who makes the following report: —

The annual inspection of Babcock machines was made in November and December of 1906. Fifty-one places were either visited or heard from, but of these only 33 came under the law requiring inspection. Those not coming within the law have no machine in many cases, and as far as can be learned neither sell nor buy on the test basis.

Of the entire number, 28 are creameries and 23 milk depots. Nineteen of the creameries are co-operative, and 9 are either proprietary or managed by stock companies. The milk depots are in nearly every case proprietary. Thirty-three machines were inspected and found in good condition, only 1 needing minor repairs. Nearly all the machines in use have cast-iron frames, and of these 16 are Facile, 8 Agos and 3 Wizard. In addition to the above, there were in use 3 steam machines having galvanized frames and 3 electrical machines. In a few cases the machines still overheat the tests, but allowance is made for this by letting them run a little longer with the cover lifted.

Most of the glassware was found in good condition, although a few still use very dirty bottles, — a practice which cannot be too strongly condemned. Beside the regular inspection, four city milk inspectors were visited; they did not care to have their machines tested.

The following parties claim they do not pay on the Babcock basis, but by the space, can, 100 pounds or quart: —

Amherst Co-operative Creamery.
Fort River Creamery of Amherst.
Leominster Creamery.
Echo Farm Dairy of South Framingham.
Fitchburg Creamery.
Boston Dairy Company of Gardner.
James Lawrence Creamery of Groton.
Este Creamery of Marlborough.
F. D. Shove Creamery of West Stockbridge.
Wachusett Creamery of Worcester.
Worcester Dairy Company.

The following is a list of the most important creameries and milk depots now in operation: —

1. *Creameries.*

Location.	Name.	President or Manager.
Amherst, ...	Amherst Co-operative, .	F. J. Humphrey, agent.
Amherst, ...	Fort River, ...	E. A. King.
Ashfield, ...	Ashfield Co-operative, .	G. G. Henry, manager.
Belchertown, . . .	Belchertown Co-operative,	M. G. Ward, president.
Cheshire (P. O. Adams), .	Greylock Co-operative, .	C. J. Fales, president.
Cheshire, ...	Highland, ...	C. W. Prince.
Cheshire, ...	West Shore, ...	S. W. Curtis.
Cummington, . . .	Cummington Co-operative,	W. E. Partridge, manager.
Easthampton, . . .	Hampton Co-operative, .	W. A. Wright, superintendent.
Egremont (P. O. North Egremont).	Egremont Co-operative, .	H. O. Harrington, manager.
Heath, ...	Cold Spring, ...	I. W. Stetson & Son.
Hinsdale, ...	Hinsdale Creamery Company.	W. C. Solomon, manager.
Lee, ...	Lee Co-operative, . .	P. A. Agnew, manager.
Leominster, ...	Leominster, ...	G. S. Wass & Co.
Montague, ...	Montague Creamery, . .	F. A. Rist, manager.
Monterey, ...	Berkshire Hills Co-operative.	D. A. Campbell, manager.
New Salem (P. O. Millington).	New Salem Co-operative, .	W. A. Moore, superintendent.
North Brookfield, . .	North Brookfield, . .	H. A. Richardson.
Northfield, ...	Northfield Co-operative, .	L. R. Smith, superintendent.
Orange (P. O. North Orange).	Orange Co-operative, . .	C. E. Dunbar, manager.
Sandisfield (P. O. New Boston).	Berkshire Co-operative, .	L. A. Bonnel, manager.
Shelburne, ...	Shelburne, ...	C. Williams, manager.
Uxbridge, ...	Farnum's Dairy, . . .	Geo. Farnum.
Warren, ...	Worcester County, . .	Gustal Hallberg, manager.
Westfield, ...	Wyben Spring Co-operative.	C. H. Wolcott, manager.
West Newbury, . . .	West Newbury Co-operative.	R. S. Brown, manager.
Williamsburg, . . .	Williamsburg Co-operative,	D. T. Clark, manager.
Worthington (P. O. Ringville).	Worthington Co-operative,	M. R. Bates, superintendent.

2. *Milk Depots.*

LOCATION.	Name.	President or Manager.
Beverly,	Cherry Hill Farm,	Henry Fielden, superintendent.
Boston (P. O. Roxbury),	Alden Bros.,	
Boston (P. O. Charlestown).	Boston Dairy Company,	W. A. Graustein, president.
Boston (P. O. Charlestown).	H. P. Hood & Sons,	
Boston,	Walker-Gordon Laboratory.	R. A. Hubbard, manager.
Boston (P. O. Charlestown).	D. Whiting & Sons,	Geo. Whiting, manager.
Cambridge,	C. Brigham Company,	J. R. Blair, superintendent.
Conway,	Boston Dairy Company,	C. P. Hassel, manager.
Everett,	N. E. Dairy Company,	F. H. Adams, manager.
Framingham (P. O. South Framingham).	Echo Farm Dairy,	J. Turner.
Fitchburg,	Fitchburg Creamery,	G. S. Learned.
Gardner,	Boston Dairy Company,	W. Fitzsimmons, manager.
Groton,	Lawrence Creamery,	M. P. Swallow, manager.
Lynn,	H. P. Hood & Sons,	E. W. Park, manager.
Marlborough,	Este's Creamery,	F. S. Este.
North Adams,	W. H. Freeman Company,	W. G. McKay, manager.
Sheffield,	Willow Brook Dairy,	G. W. Patterson, manager.
Southborough,	Deerfoot Farm Dairy,	S. H. Howes, superintendent.
Springfield,	Springfield Co-operative Milk Association.	F. B. Allen, manager.
Springfield,	Tait Bros.,	H. J. Tait, president.
West Stockbridge,	F. D. Shove Creamery,	C. E. Hardy, manager.
Worcester,	Wachusett Creamery,	E. H. Thayer & Co.
Worcester,	Worcester Dairy Company,	G. R. Bryant, manager.

THE TESTING OF PURE-BRED COWS.

Breeders of Jersey and Guernsey cows in Massachusetts continue to make yearly milk and butter fat tests of their stock under the rules of their respective national cattle clubs. This division of the station assists in the work by furnishing reputable parties who monthly visit each herd where tests are in progress, weigh each milking during twenty-four or forty-eight hours, and test the same by the Babcock for the butter fat percentage. The cost of such work consists of the tester's time at $2 to $2.50 a day, together with his travelling expenses, board and breakage. The station receives its pay from the Jersey or Guernsey clubs. There have been completed during the year 24 Guernsey and 38 Jersey records, and at present there are 8 Guernseys and 32 Jerseys undergoing yearly tests. Tests are likewise being conducted for the National Holstein-Friesian Association. These are mostly seven-day tests for milk and butter fat. Occasionally breeders test their animals for thirty and even ninety days. The test of the Holstein cow De Kol Creamelle No. 59158, belonging to Mr. D. W. Field, which yielded in one hundred days 10,017 pounds of milk containing 284.088 pounds of fat, was made by Mr. A. D. Guiel of this station. During the year 72 Holsteins have been tested, requiring the services of five men at different times during the year. The station does not publish the results obtained, but reports the same to the several cattle clubs, and keeps a duplicate record on file. It must be understood that the making of appointments for tests, the furnishing of apparatus, the securing of the necessary competent men and the verifying of the results require considerable time and thought, and necessarily interfere with the other work of this department.

Work completed.

Molasses. — There has been completed a repeated experiment with Porto Rico molasses as a food for dairy stock. Digestion tests have likewise been made, in which it is shown that molasses depresses the digestibility of the other foods with which it is fed. The entire results will be published in bulletin form. Porto Rico molasses contains some 1,100 to 1,150 pounds of digestible matter to the ton, and has about 80 per cent. of the nutritive value of corn meal.

Digestion Experiments with Sheep. — A large number of digestion experiments have been completed with sheep, and are published as Part II. of this report. Among the feeds tested may be mentioned sorghum fodder, Green Diamond sugar feed, different amounts of molasses, red and white wheats and feed barley.

The Physiological and Economical Value of Protein in Milk Secretion. — Three experiments have been completed concerning the protein requirements of dairy cows, and it is intended to publish the results in the next annual report. It was not possible to collate the data and prepare the same for publication in time for the present report.

WORK IN PROGRESS.

Alfalfa Meal. — An experiment is at present in progress to study the value of alfalfa meal as a substitute for wheat bran in milk production. It is understood to be the intention of feed jobbers in the near future to place alfalfa meal upon the market in liberal quantities as a competitor of bran, claiming it to be equal in feeding value and superior in its effect upon the general health and condition of the animal. The indications are that these claims cannot be fully substantiated.

The Effect of Molasses upon the Digestibility of Other Feed Stuffs. — German investigators have long since established the fact that the addition of considerable quantities of starch, sugar and roots depresses the digestibility of the other feeds entering into the composition of the ration. In our previous studies with Porto Rico molasses, as published elsewhere in this report, it has been shown that when molasses constituted some 25 per cent. of the dry matter of the ration, a depression of some 15 per cent. was caused in the digestibility of the latter. Other experiments are now in progress to note if smaller quantities of molasses (10 per cent. of the dry matter of the total ration) will cause relatively as large a depression as twice and thrice that amount.

The Digestibility of Proprietary Grain Rations. — Numerous grain mixtures are now upon the market as ready rations for dairy stock. The station is ascertaining the composition and particularly the digestibility of these rations as compared with home mixtures that the dairymen can prepare by purchasing the high-grade concentrates to be had in all local markets. It is believed that most of these proprietary mixtures are not as economical nor as efficient for milk production as the home mixtures.

Early Amber Sorghum. — The station has continued its observations with this plant as a summer forage crop. Different seedsmen report anywhere from 50 to 100 pounds of seed to be necessary for an acre when sown broadcast. Three twentieth-acre plots were fertilized alike, and the sorghum sown broadcast at the rate of 100, 80 and 60 pounds to the acre. The yields were nearly identical in each case, being at the rate of 20 tons of green material to the acre (harvested September 3). On another twentieth-acre plot the seed was drilled in at the rate of 15 pounds to the acre, and a yield of 19 tons to the acre was secured. This plot, however, was very weedy, and it was not possible to separate the weeds from the sorghum before weighing the crop. It is evident that when sown broadcast (which appeared to be the most economical way for forage purposes) much less seed is required to the acre than is ordinarily recommended. It is intended to repeat these trials with smaller quantities of seed.

Alfalfa. — Observations have been continued on alfalfa as a forage crop. A small piece seeded in the spring of 1905 came through the winter in good condition, and yielded three crops the present season, aggregating 3.65 tons of hay to the acre (figured at 15 per cent. moisture). Cuttings were made June 25, August 3 and September 2. A growth of six or more inches has been allowed to remain as a mulch during the winter.

A second piece, one-sixth of an acre in area, on which alfalfa had been for two years previously, but which had run out, was plowed in the spring of 1906, manured at the rate of 6 cords to the acre, limed with burnt lime at the rate of 1 ton to the acre, a fine seed bed made, and seeded with seed procured from F. E. Dawley, Fayetteville, N. Y. (locally known as Stillwell seed), and a light seeding of oats (¾ bushel to the acre). The seed came up well, and the combined alfalfa and oats were cut during July for forage. A second cutting was made in September. A third growth of six inches has been left as a mulch. It remains to be seen if this piece as well as the other above mentioned will withstand the present winter, and continue to grow without being replaced by clover and grasses. A fuller report will be made later.

Leaming v. Pride of the North Corn. — The comparative values of these two standard varieties are being studied, to ascertain if one has any particular advantage over the other for grain and silage purposes. Accurate determinations of composition and total yields, as well as of composition and yields of stalk, leaves, husks, grain and cob, have been made. The digestibility of the two varieties has also been determined. The experiment will be repeated if necessary during the season of 1907, and the completed data published as soon as possible thereafter.

Clover. — Clover was seeded together with peas and oats, barnyard millet and sorghum the present season, to see if it would not develop after these crops had been removed for soiling. If such were the case, it would save plowing and replanting, and the ground would be immediately occupied by another valuable forage crop. The clover came up well in all cases, but naturally was outstripped by the more rapidly growing annuals. After the three seedings of peas and oats had been successively cut, the clover began to grow; but a considerable growth of weeds and wild grasses also appeared, so that the heavy cutting which was made about the middle of September contained rather more grass than clover. It is possible that the clover will come in well in the spring. The millet and the sorghum grew so dense that the clover was nearly all killed out, hence it did not appear practicable to attempt its growth with such forage crops.

Changes in Staff.

Mr. S. R. Parker, who was employed for two years as dairy tester, resigned June 1, to accept a position as superintendent of agriculture at the Kamehameha Schools, Honolulu, H. T. His place was temporarily filled by the appointment of Mr. J. G. Cook, and later by Mr. H. A. Parsons, who at present fills the position most acceptably. On August 1 Mr. Cook resigned, to take the position of superintendent of the farm connected with the State Asylum for the Insane at Northampton. Mr. A. C. Whittier, who so acceptably filled the position of assistant chemist during one year, severed his connection with this division July 1, to accept a similar and more lucrative position with the Maine Experiment Station. This position was filled by the appointment of Mr. L. S. Walker, a graduate of the college in 1905. Mr. F. G. Helyar, inspector of feeds and of Babcock machines, resigned October 1, to take charge of the agricultural department connected with Mt. Hermon School, Northfield, Mass. Mr. W. K. Hepburn has been appointed to succeed him. While the writer is always pleased to see the young men connected with this division called to more responsible positions, it must be acknowledged that such changes seriously interfere with the work of the station. As a rule, it is believed it would be better economy to pay larger salaries, and retain the services of those who have proved themselves efficient workers.

PART II. — WORK IN ANIMAL NUTRITION.

J. B. LINDSEY, E. B. HOLLAND AND P. H. SMITH.

THE DIGESTIBILITY OF CATTLE FOODS.

The digestion experiments herein reported were made during the autumn, winter and early spring of 1904–05 and 1905–06, and are known as Series X and XI. The usual method was employed, an illustrated description of which is to be found in the eleventh report of the Massachusetts Experiment Station. The full data are here presented, with the exception of the daily production of manure and the daily water consumption, in which cases, to economize space, averages only are given. The periods extended over fourteen days, the first seven of which were preliminary, collection of fæces being made during the last seven. Ten grams of salt were given each sheep daily, with water *ad libitum.* Three lots of Southdown wethers were employed in the several trials, and were known as the Old Sheep, Young Sheep, and Paige Sheep. The former were fully six years of age, and the latter two lots three to four years.

SERIES X.

The results obtained in this series on the whole can be pronounced satisfactory. In periods I., II., III. and IV. the same hay was used as in the year preceding, and the digestion coefficients employed in calculating the results of these several periods were as follows:[1] —

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[1] See also seventeenth report of this station, page 46.

	Old Sheep II. and III.	Young Sheep I.	Young Sheep II.	Young Sheep III.
Dry matter,	58.50	49.89	54.34	51.53
Ash,	22.00	13.86	22.60	16.55
Protein,	42.50	37.37	37.72	36.36
Fiber,	61.00	49.98	55.85	53.13
Nitrogen-free extract,	64.00	56.29	59.77	57.02
Fat,	46.50	38.24	44.19	36.97

In all of the remaining periods a new lot of hay was used, and the following coefficients were employed, being the average of those secured for each group of sheep: —

	Old Sheep.	Young Sheep.	Paige Sheep.
Dry matter,	60.72	57.07	57.98
Ash,	45.50	43.64	40.52
Protein,	53.69	47.37	53.61
Fiber,	63.79	57.55	59.06
Nitrogen-free extract,	63.08	61.11	61.41
Fat,	50.24	51.71	47.76

The composition of the old hay used in the first four periods was taken to be the same as was shown by the two analyses made in the preceding year. The composition of the new hay represents the average of three analyses. The average of the several analyses follows: —

	Old Hay, **1903-04.**	New Hay, **1904-05.**
Ash,	6.44	8.20
Protein,	6.24	8.69
Fiber,	32.48	32.14
Nitrogen-free extract,	52.70	48.56
Fat,	2.14	2.41

Composition of Feed Stuffs (Per Cent.).

[Dry Matter.]

FEEDS.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Soy bean fodder,	9.17	21.69	27.83	37.75	3.56
Blomo feed,	10.73	17.23	13.14	58.28	0.62
Malt sprouts,	6.58	28.65	15.29	47.70	1.78
Sucrene dairy feed,	6.17	18.48	14.11	56.95	4.29
Holstein sugar feed,	7.31	13.73	10.88	65.14	2.94
Macon sugar feed,	6.83	15.16	10.20	66.11	1.70
Hominy feed,	2.78	11.59	5.28	71.54	8.81
Buckwheat middlings,	4.82	28.23	8.95	50.61	7.39
Oat middlings,	2.61	17.72	2.56	69.47	7.64
Eureka silage corn stover,	6.96	8.00	36.49	47.16	1.39
Waste Eureka silage corn stover, Sheep II.,	8.50	6.71	41.89	41.89	1.01
Waste Eureka silage corn stover, Sheep III.,	7.45	6.02	42.84	42.48	1.21
Pride of the North corn stover,	6.77	7.23	34.45	50.01	1.54
Waste Pride of the North corn stover, Sheep II.	7.64	4.27	40.94	45.65	1.50
Waste Pride of the North corn stover, Sheep III.	6.88	3.76	40.74	47.14	1.48
Digestion hay fed to Paige Sheep IV.,	7.82	8.56	32.35	48.75	2.52
Digestion hay fed to Young Sheep,	8.43	8.70	32.17	48.33	2.37
Digestion hay fed to Old Sheep and Paige Sheep V.	8.35	8.80	31.89	48.62	2.34
Average for digestion hay (three trials),	8.20	8.69	32.14	48.56	2.41

Composition of Fæces (Per Cent.).

[Dry Matter.]

Old Sheep II.

Periods.	FEEDS.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
II.,	Blomo feed,	15.41	11.93	25.59	44.81	2.26
IV.,	Sucrene feed,	11.92	12.32	26.50	47.05	2.21
V.,	Eureka silage corn stover,	7.96	8.75	34.10	48.16	1.03
VII.,	Pride of the North corn stover,	9.54	8.81	30.27	50.17	1.21
IX.,	Digestion hay,	11.48	10.22	29.56	45.71	3.03
XI.,	Macon sugar feed,	13.17	12.90	27.09	44.26	2.58

Composition of Fæces (Per Cent.) — Concluded.

Old Sheep III.

Periods.	FEEDS.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
II.,	Blomo feed,	16.33	13.38	23.99	43.92	2.38
IV.,	Sucrene feed,	12.53	13.04	24.84	47.34	2.25
V.,	Eureka silage corn stover,	8.67	9.73	30.51	50.05	1.04
VII.,	Pride of the North corn stover,	10.62	9.41	27.95	50.84	1.18
IX.,	Digestion hay,	11.68	10.52	29.23	45.67	2.90
XI.,	Macon sugar feed,	13.57	13.75	26.40	43.90	2.38
	Young Sheep I.					
I.,	Soy bean fodder,	13.22	10.02	36.33	37.43	3.00
III.,	Malt sprouts,	12.97	11.19	27.80	45.42	2.62
VIII.,	Digestion hay,	10.92	10.26	32.09	44.01	2.72
X.,	Holstein sugar feed,	13.10	12.80	28.36	43.50	2.24
XIII.,	Buckwheat middlings,	11.52	11.74	32.08	41.79	2.87
	Young Sheep II.					
I.,	Soy bean fodder,	13.19	10.36	36.24	37.20	3.01
III.,	Malt sprouts,	13.11	11.72	26.74	45.93	2.50
VIII.,	Digestion hay,	11.57	11.18	30.46	44.06	2.73
X.,	Holstein sugar feed,	13.06	12.80	27.49	44.32	2.33
XIII.,	Buckwheat middlings,	11.23	12.84	31.65	41.58	2.70
	Young Sheep III.					
I.,	Soy bean fodder,	13.40	9.72	36.36	37.64	2.88
III.,	Malt sprouts,	12.93	11.20	28.13	45.28	2.46
VIII.,	Digestion hay,	10.75	10.60	32.81	43.29	2.55
X.,	Holstein sugar feed,	11.65	11.42	30.23	44.41	2.29
XIII.,	Buckwheat middlings,	10.62	11.31	32.98	42.26	2.83
	Paige Sheep IV.					
VI.,	Digestion hay,	11.61	9.90	30.66	44.91	2.92
XII.,	Hominy feed,	12.17	12.75	27.63	43.68	3.77
XIV.,	Oat middlings,	12.52	12.52	28.81	42.82	3.33
	Paige Sheep V.					
IX.,	Digestion hay,	11.23	9.24	31.93	44.49	3.11
XII.,	Hominy feed,	11.02	11.69	28.64	44.93	3.72
XIV.,	Oat middlings,	11.81	12.39	29.35	43.31	3.14

Dry Matter Determinations made at Time of weighing out the Different Foods, and Dry Matter in Manure excreted, determined from Air-dry Fæces (Per Cent.).

Old Sheep II.

Periods.	English Hay.	Blomo Feed.	Sucrene Feed.	Eureka Silage Corn Stover.	Pride of the North Corn Stover.	Macon Sugar Feed.	Waste.	Fæces.
II., . .	87.70	81.77	-	-	-	-	-	91.35
IV., . .	87.35	-	86.87	-	-	-	-	93.61
V., . .	-	-	-	37.11	-	-	43.15	94.16
VII., . .	-	-	-	-	81.87	-	88.89	94.22
IX., . .	89.77	-	-	-	-	-	-	95.03
XI., . .	90.30	-	-	-	-	94.45	-	93.96

Old Sheep III.

Periods.	English Hay.	Blomo Feed.	Sucrene Feed.	Eureka Silage Corn Stover.	Pride of the North Corn Stover.	Macon Sugar Feed.	Waste.	Fæces.
II., . .	87.70	81.77	-	-	-	-	-	91.42
IV., . .	87.35	-	86.87	-	-	-	-	93.64
V., . .	-	-	-	37.11	-	-	45.63	93.96
VII., . .	-	-	-	-	81.87	-	85.63	94.03
IX., . .	89.77	-	-	-	-	-	-	94.84
XI., . .	90.30	-	-	-	-	94.45	-	93.57

Dry Matter Determinations, etc. — Continued.

Young Sheep I.

Periods.	English Hay.	Soy Bean Fodder.	Malt Sprouts.	Holstein Sugar Feed.	Buckwheat Middlings.	Waste.	Fæces.
I., ...	88.40	20.64	-	-	-	-	89.51
III., ...	88.02	-	84.68	-	-	-	93.09
VIII., ...	88.52	-	-	-	-	-	93.97
X., ...	89.90	-	-	91.66	-	-	94.15
XIII., ...	90.55	-	-	-	90.74	-	94.40

Young Sheep II.

Periods.	English Hay.	Soy Bean Fodder.	Malt Sprouts.	Holstein Sugar Feed.	Buckwheat Middlings.	Waste.	Fæces.
I., ...	88.40	20.64	-	-	-	-	89.44
III., ...	88.02	-	84.68	-	-	-	92.93
VIII., ...	88.52	-	-	-	-	-	94.01
X., ...	89.90	-	-	91.66	-	-	94.19
XIII., . . .	90.55	-	-	-	90.74	-	93.91

Dry Matter Determinations, etc. — Continued.

Young Sheep III.

PERIODS.	English Hay.	Soy Bean Fodder.	Malt Sprouts.	Holstein Sugar Feed.	Buckwheat Middlings.	Waste.	Fæces.
I., ...	88.40	20.64	–	–	–	–	89.54
IV., ...	88.02	–	84.68	–	–	–	93.13
VIII., ...	88.52	–	–	–	–	–	93.91
X., ...	89.90	–	–	91.66	–	–	94.35
XIII., ...	90.55	–	–	–	90.74	–	94.28

Dry Matter Determinations, etc. — Concluded.

Paige Sheep IV.

PERIODS.	English Hay.	Hominy Feed.	Oat Middlings.	Waste.	Fæces.
VI., ...	88.35	–	–	–	93.35
XII., ...	90.62	90.94	–	–	94.09
XIV., ...	90.45	–	91.07	–	93.73

Paige Sheep V.

PERIODS.	English Hay.	Hominy Feed.	Oat Middlings.	Waste.	Fæces.
IX., ...	89.77	–	–	–	95.08
XII., ...	90.62	90.94	–	–	94.20
XIV., ...	90.45	–	91.07	–	93.52

Average Daily Amount of Manure excreted and Water drank (Grams).

Old Sheep II.

Periods.	CHARACTER OF RATION.	Manure excreted daily.	Sample Air Dry.	Water drank daily.
II.,	Blomo feed, ...	671	32.80	1,306
IV.,	Sucrene feed, ...	751	31.15	1,144
V.,	Eureka silage corn stover, ...	765	31.07	lost.
VII.,	Pride of the North corn stover, . . .	1,058	37.63	1,667
IX.,	Digestion hay, ...	775	32.54	1,643
XI.,	Macon sugar feed, ...	739	31.99	1,592

Old Sheep III.

Periods.	CHARACTER OF RATION.	Manure excreted daily.	Sample Air Dry.	Water drank daily.
II.,	Blomo feed, ...	675	30.83	1,578
IV.,	Sucrene feed, ...	867	32.31	1,606
V.,	Eureka silage corn stover, ...	921	28.91	804
VII.,	Pride of the North corn stover, . . .	1,123	34.40	2,500
IX.,	Digestion hay, ...	1,107	34.30	2,430
XI.,	Macon sugar feed, ...	1,155	31.21	2,227

Average Daily Amount of Manure excreted and Water drank (Grams) — Concluded.

Young Sheep I.

Periods.	CHARACTER OF RATION.	Manure excreted daily.	Sample Air Dry.	Water drank daily.
I.,	Soy bean fodder, ...	615	30.28	188
III.,	Malt sprouts, ...	870	30.43	1,392
VIII.,	Digestion hay, ...	961	33.17	1,693
X.,	Holstein sugar feed, ...	1,008	29.21	1,608
XIII.,	Buckwheat middlings, ...	743	28.62	1,689

Young Sheep II.

I.,	Soy bean fodder, ...	573	30.70	1,169
III.,	Malt sprouts, ...	746	30.48	2,334
VIII.,	Digestion hay, ...	984	30.86	2,471
X.,	Holstein sugar feed, ...	868	28.04	2,249
XIII.,	Buckwheat middlings, ...	882	27.91	2,410

Young Sheep III.

I.,	Soy bean fodder, ...	638	32.68	1,666
III.,	Malt sprouts, ...	791	30.86	2,486
VIII.,	Digestion hay, ...	1,152	33.02	2,500
X.,	Holstein sugar feed, ...	743	29.30	2,335
XIII.,	Buckwheat middlings, ...	699	29.59	2,486

Paige Sheep IV.

VI.,	Digestion hay, ...	–	–	–
IX.,	Digestion hay, ...	–	–	–
XII.,	Hominy feed, ...	596	25.37	1,901
XIV.,	Oat middlings, ...	598	24.85	1,924

Paige Sheep V.

VI.,	Digestion hay, ...	–	–	–
IX.,	Digestion hay, ...	699	31.41	1,924
XII.,	Hominy feed, ...	630	26.31	1,666
XIV.,	Oat middlings, ...	661	25.85	1,814

Weights of Animals at Beginning and End of Period (Pounds).

Old Sheep II.

Periods.	Character of Ration.	Beginning.	End.
II.,	Blomo feed, ...	154.75	152.00
IV.,	Sucrene feed, ...	156.50	157.75
V.,	Eureka silage corn stover, ...	156.50	154.00
VII.,	Pride of the North corn stover, ...	154.50	157.00
IX.,	Digestion hay, ...	158.25	157.25
XI.,	Macon sugar feed, ...	160.00	157.75

Old Sheep III.

Periods.	Character of Ration.	Beginning.	End.
II.,	Blomo feed, ...	163.00	160.00
IV.,	Sucrene feed, ...	164.25	162.25
V.,	Eureka silage corn stover, ...	163.25	163.00
VII.,	Pride of the North corn stover, ...	164.50	161.00
IX.,	Digestion hay, ...	167.00	165.25
XI.,	Macon sugar feed, ...	164.00	164.25

Young Sheep I.

Periods.	Character of Ration.	Beginning.	End.
I.,	Soy bean fodder, ...	101.50	99.75
III.,	Malt sprouts, ...	109.50	109.75
VIII.,	Digestion hay, ...	120.00	116.00
X.,	Holstein sugar feed, ...	116.00	114.25
XIII.,	Buckwheat middlings, ...	113.00	114.00

Young Sheep II.

Periods.	Character of Ration.	Beginning.	End.
I.,	Soy bean fodder, ...	102.50	101.00
III.,	Malt sprouts, ...	110.50	108.50
VIII.,	Digestion hay, ...	122.00	120.00
X.,	Holstein sugar feed, ...	115.75	116.00
XIII.,	Buckwheat middlings, ...	115.25	116.00

Young Sheep III.

Periods.	Character of Ration.	Beginning.	End.
I.,	Soy bean fodder, ...	97.00	95.75
III.,	Malt sprouts, ...	102.25	101.50
VIII.,	Digestion hay, ...	111.00	107.50
X.,	Holstein sugar feed, ...	106.00	106.00
XIII.,	Buckwheat middlings, ...	106.50	106.50

Weights of Animals, etc. — Concluded.

Paige Sheep IV.

Periods.	CHARACTER OF RATION.	Beginning.	End.
VI.,	Digestion hay, ...	156.00	155.50
IX.,	Digestion hay, ...	–	–
XII.,	Hominy feed, ...	154.50	152.00
XIV.,	Oat middlings, ...	155.50	155.00

Paige Sheep V.

VI.,	Digestion hay, ...	–	–
IX.,	Digestion hay, ...	133.25	137.75
XII.,	Hominy feed, ...	140.00	140.25
XIV.,	Oat middlings, ...	141.00	143.25

Period I.

Young Sheep I.

DAILY RECORD.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
350 grams English hay fed, . . .	309.40	19.93	19.31	100.49	163.05	6.62
1,800 grains soy bean fodder fed, . .	371.52	34.07	80.58	103.39	140.25	13.23
Amount consumed, ...	680.92	54.00	99.89	203.88	303.30	19.85
302.84 grams manure excreted, . .	271.07	35.84	27.16	98.48	101.46	8.13
Grams digested, ...	409.85	18.16	72.73	105.40	201.84	11.72
Minus hay digested, ...	154.36	2.76	7.22	50.22	91.78	2.55
Soy bean fodder digested, ...	255.49	15.40	65.51	55.18	110.06	9.17
Per cent. digested, ...	68.77	45.20	81.30	53.37	78.47	69.31

Young Sheep II.

Amount consumed as above, ...	680.92	54.00	99.89	203.88	303.30	19.85
307.13 grams manure excreted, . .	274.70	36.23	28.46	99.55	102.19	8.27
Grams digested, ...	406.22	17.77	71.43	104.33	201.11	11.58
Minus hay digested, ...	168.13	4.50	7.28	56.12	97.45	2.93
Soy bean fodder digested, ...	238.09	13.27	64.15	48.21	103.66	8.65
Per cent. digested, ...	64.09	38.95	79.61	46.63	73.91	65.38

Period I. — Concluded.

Young Sheep III.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, ...	680.92	54.00	99.89	203.88	303.30	19.85
326.78 grams manure excreted, . .	292.60	39.21	28.44	106.39	110.13	8.43
Grams digested, ...	388.32	14.79	71.45	97.49	193.17	11.42
Minus hay digested, ...	159.43	3.30	7.08	53.39	92.97	2.45
Soy bean fodder digested, . . .	228.89	11.49	64.37	44.10	100.20	8.97
Per cent. digested, ...	61.61	33.72	79.88	42.65	71.44	67.80
Average per cent. three sheep digested,	64.82	39.29	80.26	47.55	74.61	67.50

Average nutritive ratio of rations for three sheep, 1:4.54.

Period II.

Old Sheep II.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
500 grams English hay fed, . . .	438.50	28.24	27.36	142.42	231.09	9.38
400 grams Blomo feed fed, . . .	327.08	35.10	56.36	42.98	190.62	2.03
Amount consumed, ...	765.58	63.34	83.72	185.40	421.71	11.41
328.04 grams manure excreted, . .	299.66	46.18	35.75	76.68	134.28	6.77
Grams digested, ...	465.92	17.16	47.97	108.72	287.43	4.64
Minus hay digested, ...	256.52	6.21	11.63	86.88	147.90	4.36
Blomo feed digested, ...	209.40	10.95	36.34	21.84	139.53	.28
Per cent. digested, ...	64.02	31.20	64.48	50.81	73.20	13.79

Old Sheep III.

Amount consumed as above, ...	765.58	63.34	83.72	185.40	421.71	11.41
308.33 grams manure excreted, . .	281.88	46.03	37.72	67.62	123.80	6.71
Grams digested, ...	483.70	17.31	46.00	117.78	297.91	4.70
Minus hay digested, ...	256.52	6.21	11.63	86.88	147.90	4.36
Blomo feed digested, ...	227.18	11.10	34.37	30.90	150.01	.34
Per cent. digested, ...	69.46	31.62	60.98	71.89	78.70	16.75
Average per cent. two sheep digested,	66.74	31.41	62.73	61.35	75.95	15.27

Average nutritive ratio of rations for two sheep, 1:8.86.

Period III.

Young Sheep I.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed,	528.12	34.01	32.95	171.53	278.32	11.30
200 grams malt sprouts fed,	169.36	11.14	48.52	25.90	80.78	3.01
Amount consumed,	697.48	45.15	81.47	197.43	359.10	14.31
304.24 grams manure excreted,	283.22	36.73	31.69	78.74	128.64	7.42
Grams digested,	414.26	8.42	49.78	118.69	230.46	6.89
Minus hay digested,	263.48	4.71	12.31	85.73	156.67	4.32
Malt sprouts digested,	150.78	3.71	37.47	32.96	73.79	2.57
Per cent. digested,	89.03	33.30	77.23	100+	91.35	85.38

Young Sheep II.

Amount consumed as above,	697.48	45.15	81.47	197.43	359.10	14.31
304.81 grams manure excreted,	283.26	37.14	33.20	75.74	130.10	7.08
Grams digested,	414.22	8.01	48.27	121.69	229.00	7.23
Minus hay digested,	286.98	7.69	12.43	95.80	166.35	4.99
Malt sprouts digested,	127.24	.32	35.84	25.89	62.65	2.24
Per cent. digested,	75.13	2.87	73.87	100.00	77.56	74.42

Young Sheep III.

Amount consumed as above,	697.48	45.15	81.47	197.43	359.10	14.31
308.60 grams manure excreted,	287.40	37.16	32.19	80.85	130.13	7.07
Grams digested,	410.08	7.99	49.28	116.56	228.97	7.24
Minus hay digested,	272.14	5.63	12.08	91.13	158.70	4.18
Malt sprouts digested,	137.94	2.36	37.20	25.45	70.27	3.06
Per cent. digested,	81.45	21.18	76.67	98.26	86.99	100+
Average per cent. three sheep digested,	81.87	19.12	75.92	99.42	85.30	86.60

Average nutritive ratio of rations for three sheep, 1:7.42.

Period IV.

Old Sheep II.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed,	524.10	33.75	32.70	170.23	276.20	11.22
300 grams Sucrene dairy feed fed,	260.61	16.08	48.16	36.77	148.42	11.18
Amount consumed,	784.71	49.83	80.86	207.00	424.62	22.40
311.47 grams manure excreted,	291.57	34.76	35.92	77.27	137.18	6.44
Grams digested,	493.14	15.07	44.94	129.73	287.44	15.96
Minus hay digested,	306.60	7.43	13.90	103.84	176.77	5.22
Sucrene dairy feed digested,	186.54	7.64	31.04	25.89	110.67	10.74
Per cent. digested,	71.58	47.51	64.45	70.41	74.57	96.06

Old Sheep III.

Amount consumed as above,	784.71	49.83	80.86	207.00	424.62	22.40
323.07 grams manure excreted,	302.52	37.91	39.45	75.15	143.21	6.81
Grams digested,	482.19	11.92	41.41	131.85	281.41	15.59
Minus hay digested,	306.60	7.43	13.90	103.84	176.77	5.22
Sucrene dairy feed digested,	175.59	4.49	27.51	27.01	104.64	10.37
Per cent. digested,	67.38	27.92	57.12	73.46	70.50	92.75
Average per cent. two sheep digested,	69.48	37.72	60.79	71.94	72.54	94.41

Average nutritive ratio of rations for two sheep, 1:10.4.

Period V.

Old Sheep II.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
1,800 grams Eureka silage corn stover,	667.98	46.49	53.44	243.75	315.02	9.28
Minus 89 grams waste,	38.40	3.26	2.58	16.09	16.09	.38
Amount consumed,	629.58	43.23	50.86	227.66	298.93	8.90
310.74 grams manure excreted,	292.59	23.29	25.60	99.77	140.91	3.01
Grams digested,	336.99	19.94	25.26	129.89	158.02	5.89
Per cent. digested,	53.53	46.13	49.67	56.18	52.86	66.18

Period V. — Concluded.

Old Sheep III.

DAILY RECORD.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
1,800 grams Eureka silage corn stover,	667.98	46.49	53.44	243.75	315.02	9.28
Minus 133.20 grams waste, . . .	60.78	4.53	3.66	26.04	25.82	0.74
Amount consumed, ...	607.20	41.96	49.78	217.71	289.20	8.54
289.07 grams manure excreted, . .	271.61	23.55	26.43	82.87	135.94	2.82
Grams digested, ...	335.59	18.41	23.35	134.84	153.26	5.72
Per cent. digested, ...	55.27	43.88	46.91	61.94	52.99	66.98
Average per cent. two sheep digested,	54.40	45.01	48.29	59.06	52.93	66.58

Average nutritive ratio of rations for two sheep, 1: 12.3.

Period VI.

Paige Sheep IV.

DAILY RECORD.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed, . . .	706.80	55.27	60.50	228.65	344.57	17.81
321.50 grams manure excreted, . .	300.12	34.84	29.71	92.02	134.78	8.76
Grams digested, ...	406.68	20.43	30.79	136.63	209.79	9.05
Per cent. digested, ...	57.54	36.96	50.89	59.76	60.88	50.81

Nutritive ratio of ration, 1: 11.9.

Period VII.

Old Sheep II.

DAILY RECORD.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
1,000 grams Pride of the North corn stover.	818.70	55.43	59.19	282.04	409.43	12.61
Minus 74.64 grams waste, . . .	66.35	5.07	2.83	27.16	30.29	1.00
Amount consumed, ...	752.35	50.36	56.36	254.88	379.14	11.61
376.31 grams manure excreted, . .	354.56	33.83	31.24	107.33	177.88	4.29
Grams digested, ...	397.79	16.53	25.12	147.55	201.26	7.32
Per cent. digested, ...	52.87	32.82	44.57	57.89	53.08	63.05

Period VII. — Concluded.

Old Sheep III.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
1,000 grams Pride of the North corn stover.	818.70	55.43	59.19	282.04	409.43	12.61
Minus 115.45 grams waste,	98.86	6.80	3.72	40.28	46.60	1.46
Amount consumed,	719.84	48.63	55.47	241.76	362.83	11.15
344.01 grams manure excreted,	323.47	34.35	30.44	90.41	164.45	3.82
Grams digested,	396.37	14.28	25.03	151.35	198.38	7.33
Per cent. digested,	55.06	29.36	45.12	62.60	54.68	65.75
Average per cent. two sheep digested,	53.97	31.09	44.85	60.25	53.88	64.40

Average nutritive ratio of rations for two sheep, 1:14.6.

Period VIII.

Young Sheep I.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed,	708.16	59.70	61.61	227.82	342.25	16.78
331.74 grams manure excreted,	311.74	34.04	31.98	100.04	137.20	8.48
Grams digested,	396.42	25.66	29.63	127.78	205.05	8.30
Per cent. digested,	55.98	42.98	48.09	56.09	59.91	49.46

Young Sheep II.

800 grams English hay fed,	708.16	59.70	61.61	227.82	342.25	16.78
308.60 grams manure excreted,	290.11	33.57	32.43	88.37	127.82	7.92
Grams digested,	418.05	26.13	29.18	139.45	214.43	8.86
Per cent. digested,	59.03	43.77	47.36	61.21	62.65	52.80

Young Sheep III.

800 grams English hay fed,	708.16	59.70	61.61	227.82	342.25	16.78
330.18 grams manure excreted,	310.07	33.33	32.87	101.73	134.23	7.91
Grams digested,	398.09	26.37	28.74	126.09	208.02	8.87
Per cent. digested,	56.21	44.17	46.65	55.35	60.78	52.86
Average per cent. three sheep digested,	57.07	43.64	47.37	57.55	61.11	51.71

Average nutritive ratio of rations for three sheep, 1:12.3.

Period IX.

Old Sheep II.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
900 grams English hay fed,	807.93	67.46	71.10	257.65	392.82	18.91
325.43 grams manure excreted,	309.26	35.50	31.61	91.42	141.36	9.37
Grams digested,	498.67	31.96	39.49	166.23	251.46	9.54
Per cent. digested,	61.72	47.36	55.54	64.52	64.01	50.45

Old Sheep III.

900 grams English hay fed,	807.93	67.46	71.10	257.65	392.82	18.91
343 grams manure excreted,	325.30	38.00	34.22	95.09	148.56	9.43
Grams digested,	482.63	29.46	36.88	162.56	244.26	9.47
Per cent. digested,	59.74	43.67	51.87	63.09	62.18	50.08

Paige Sheep V.

800 grams English hay fed,	718.16	59.97	63.20	229.02	349.17	16.80
314.13 grams manure excreted,	298.67	33.54	27.60	95.37	132.88	9.29
Grams digested,	419.49	26.43	35.60	133.65	216.29	7.51
Per cent. digested,	58.41	44.07	56.33	58.36	61.94	44.70
Average per cent. three sheep digested,	60.73	45.52	53.71	63.81	63.10	50.27

Average nutritive ratio of rations for three sheep, 1:11.3.

Period X.

Young Sheep I.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
500 grams English hay fed,	449.50	36.86	39.06	144.47	218.28	10.83
300 grams Holstein sugar feed,	274.98	20.10	37.75	29.92	179.12	8.08
Amount consumed,	724.48	56.96	76.81	174.39	397.40	18.91
292.11 grams manure excreted,	275.02	36.03	35.20	78.00	119.63	6.16
Grams digested,	449.46	20.93	41.61	96.39	277.77	12.75
Minus hay digested,	256.53	16.09	18.50	83.14	133.39	5.60
Holstein sugar feed digested,	192.93	4.84	23.11	13.25	144.38	7.15
Per cent. digested,	70.16	24.08	61.22	44.28	80.61	88.49

Period X. — Concluded.

Young Sheep II.

DAILY RECORD.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	724.48	56.96	76.81	174.39	397.40	18.91
280.41 grams manure excreted,	264.12	34.49	33.81	72.61	117.06	6.15
Grams digested,	460.36	22.47	43.00	101.78	280.34	12.76
Minus hay digested,	256.53	16.09	18.50	83.14	133.39	5.60
Holstein sugar feed digested,	203.83	6.38	24.50	18.64	146.95	7.16
Per cent. digested,	74.13	31.74	64.90	62.30	82.04	88.61

Young Sheep III.

Amount consumed as above,	724.48	56.96	76.81	174.39	397.40	18.91
293.03 grams manure excreted,	276.47	32.21	31.57	83.58	122.78	6.33
Grams digested,	448.01	24.75	45.24	90.81	274.62	12.58
Minus hay digested,	256.53	16.09	18.50	83.14	133.39	5.60
Holstein sugar feed digested,	191.48	8.66	26.74	7.67	141.23	6.98
Per cent. digested,	69.63	43.08	70.83	25.64	78.85	86.39
Average per cent. three sheep digested,	71.31	32.97	65.65	44.07	80.50	87.83

Average nutritive ratio of rations for three sheep, 1:9.3.

Period XI.

Old Sheep I.

DAILY RECORD.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed,	541.80	44.43	47.08	174.13	263.10	13.06
300 grams Macon sugar feed,	283.35	19.35	42.96	28.90	187.32	4.82
Amount consumed,	825.15	63.78	90.04	203.03	450.42	17.88
319.90 grams manure excreted,	300.58	39.59	38.77	81.43	133.04	7.75
Grams digested,	524.57	24.19	51.27	121.60	317.38	10.13
Minus hay digested,	328.98	20.22	25.28	111.08	165.96	6.56
Macon sugar feed digested,	195.59	3.97	25.99	10.52	151.42	3.57
Per cent. digested,	69.03	20.52	60.50	36.40	80.83	74.07

Period XI. — Concluded.

Old Sheep III.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . . .	825.15	63.78	90.04	203.03	450.42	17.88
312.14 grams manure excreted, . .	292.07	39.63	40.16	77.11	128.22	6.95
Grams digested, ...	533.08	24.15	49.88	125.92	322.20	10.93
Minus hay digested, ...	328.98	20.22	25.28	111.08	165.96	6.56
Macon sugar feed digested, . . .	204.10	3.93	24.60	14.84	156.24	4.37
Per cent. digested, ...	72.03	20.31	57.26	51.35	83.41	90.66
Average per cent. two sheep digested,	70.53	20.42	58.88	43.88	82.12	82.37

Average nutritive ratio of rations for two sheep, 1 : 9.2.

Period XII.

Paige Sheep IV.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed, . . .	498.41	40.87	43.31	160.19	242.03	12.01
300 grams hominy feed, ...	272.22	7.57	31.55	14.37	194.75	23.98
Amount consumed, ...	770.63	48.44	74.86	174.56	436.78	35.99
253.67 grams manure excreted, . .	238.68	29.05	30.43	65.95	104.26	9.00
Grams digested, ...	531.95	19.39	44.43	108.61	332.52	26.99
Minus hay digested, ...	288.98	16.56	23.22	94.61	148.63	5.74
Hominy feed digested, ...	242.97	2.83	21.21	14.00	183.89	21.25
Per cent. digested, ...	89.26	37.38	67.23	97.43	94.42	88.62

Paige Sheep V.

Amount consumed as above, . . .	770.63	48.44	74.86	174.56	436.78	35.99
263.07 grams manure excreted, . .	247.81	27.31	28.97	70.97	111.34	9.22
Grams digested, ...	522.82	21.13	45.89	103.59	325.44	26.77
Minus hay digested, ...	288.98	16.56	23.22	94.61	148.63	5.74
Hominy feed digested, ...	233.84	4.57	22.67	8.98	176.81	21.03
Per cent. digested, ...	85.90	60.37	71.85	62.49	90.79	87.70
Average per cent. two sheep digested,	87.58	48.88	69.54	79.96	92.61	88.16

Average nutritive ratio of rations for two sheep, 1 : 10.9.

Period XIII.

Young Sheep I.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed,	498.03	40.84	43.28	160.07	241.84	12.00
250 grams buckwheat middlings,	226.85	10.93	64.04	20.30	114.81	16.76
Amount consumed,	724.88	51.77	107.32	180.37	356.65	28.76
286.23 grams manure excreted,	270.20	31.13	31.72	86.68	112.92	7.75
Grams digested,	454.68	20.64	75.60	93.69	243.73	21.01
Minus hay digested,	284.23	17.82	20.50	92.12	147.79	6.21
Buckwheat middlings digested,	170.45	2.82	55.10	1.57	95.94	14.80
Per cent. digested,	75.14	25.80	86.04	7.73	83.56	88.31

Young Sheep II.

Amount consumed as above,	724.88	51.77	107.32	180.37	356.65	28.76
279.07 grams manure excreted,	262.07	29.43	33.65	82.95	108.97	7.08
Grams digested,	462.81	22.34	73.67	97.42	247.68	21.68
Minus hay digested,	284.23	17.82	20.50	92.12	147.79	6.21
Buckwheat middlings digested,	178.58	4 52	53.17	5.30	99.89	15.47
Per cent. digested,	78.72	41.35	83.03	26.11	87.00	92.30

Young Sheep III.

Amount consumed as above,	724.88	51.77	107.32	180.37	356.65	28.76
295.90 grams manure excreted,	278.97	29.63	31.55	92.00	117.89	7.89
Grams digested,	445.91	22.14	75.77	88.37	238.76	20.87
Minus hay digested,	284.23	17.82	20.50	92.12	147.79	6.21
Buckwheat middlings digested,	161.68	4.32	55.27	–	90.97	14.66
Per cent. digested,	71.27	39.52	86.31	–	79.24	87.47
Average per cent. three sheep digested,	75.04	35.56	85.13	16.92[1]	83.27	89.36

Average nutritive ratio of rations for three sheep, 1: 5.1.

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[1] Average two sheep.

Period XIV.

Paige Sheep IV.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed, . . .	497.48	40.79	43.23	159.89	241.58	11.99
300 grams oat middlings, . . .	273.21	7.13	48.41	6.99	189.80	20.87
Amount consumed, ...	770.69	47.92	91.64	166.88	431.38	32.86
248.47 grams manure excreted, . .	232.89	29.16	29.16	67.10	99.72	7.76
Grams digested, ...	537.80	18.76	62.48	99.78	331.66	25.10
Minus hay digested, ...	288.44	16.53	23.18	94.43	148.35	5.73
Oat middlings digested, ...	249.36	2.23	39.30	5.35	183.31	19.37
Per cent. digested, ...	91.27	31.28	81.18	76.54	96.58	92.81

Paige Sheep V.

Daily Record.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . .	770.69	47.92	91.64	166.88	431.38	32.86
258.53 grams manure excreted, . .	241.78	28.55	29.96	70.96	104.71	7.59
Grams digested, ...	528.91	19.37	61.68	95.92	326.67	25.27
Minus hay digested, ...	288.44	16.53	23.18	94.43	148.35	5.73
Oat middlings digested, ...	240.47	2.84	38.50	1.49	178.32	19.54
Per cent. digested, ...	88.02	39.83	79.53	21.32	93.95	93.63
Average per cent. two sheep digested,	89.65	35.56	80.36	48.93	95.27	93.22

Average nutritive ratio of rations for two sheep, 1:7.8.

Summary of Coefficients.

Coefficients determined on —	Sheep Number.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Soybean fodder,	Young Sheep I., .	68.77	45.20	81.30	53.37	78.47	69.31
	Young Sheep II.,	64.09	38.95	79.61	46.63	73.91	65.38
	Young Sheep III.,	61.61	33.72	79.88	42.65	71.44	67.80
	Average, . .	64.82	39.29	80.26	47.55	74.61	67.50
Blomo feed, .	Old Sheep II., .	64.02	31.20	64.48	50.81	73.20	13.79
	Old Sheep III., .	69.46	31.62	60.98	71.89	78.70	16.75
	Average, . .	66.74	31.41	62.73	61.35	75.95	15.27
Malt sprouts, .	Young Sheep I., .	89.03	33.30	77.23	100+	91.35	85.38
	Young Sheep II., .	75.13	2.87	73.87	100+	77.56	74.42
	Young Sheep III.,	81.45	21.18	76.67	98.26	86.99	100+
	Average, . .	81.87	19.12	75.92	99.42	85.30	86.60
Sucrene dairy feed.	Old Sheep II., .	71.58	47.51	64.45	70.41	74.57	96.06
	Old Sheep III., .	67.38	27.92	57.12	73.46	70.50	92.75
	Average, . .	69.48	37.72	60.79	71.94	72.54	94.41

Summary of Coefficients — Concluded.

COEFFICIENTS DETERMINED ON —	Sheep Number.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Holstein sugar feed.	Young Sheep I., .	70.16	24.08	61.22	44.28	80.61	88.49
	Young Sheep II.,	74.13	31.74	64.90	62.30	82.04	88.61
	Young Sheep III.,	69.63	43.08	70.83	25.64	78.85	86.39
	Average, . .	71.31	32.97	65.65	44.07	80.50	87.83
Macon sugar feed.	Old Sheep II., .	69.03	20.52	60.50	36.40	80.83	74.07
	Old Sheep III., .	72.03	20.31	57.26	51.35	83.41	90.66
	Average, . .	70.53	20.42	58.88	43.88	82.12	82.37
Hominy feed, .	Paige Sheep IV.,	89.26	37.38	67.23	97.43	94.42	88.62
	Paige Sheep V., .	85.90	60.37	71.85	62.49	90.79	87.70
	Average, . .	87.58	48.88	69.54	79.96	92.61	88.16
Buckwheat middlings.	Young Sheep I., .	75.14	25.80	86.04	7.73	83.56	88.31
	Young Sheep II.,	78.72	41.35	83.03	26.11	87.00	92.30
	Young Sheep III.,	71.27	39.52	86.31	–	79.24	87.47
	Average, . .	75.04	35.56	85.13	16.92	83.27	89.36
Oat middlings,	Paige Sheep IV.,	91.27	31.28	81.18	76.54	96.58	92.81
	Paige Sheep V., .	88.02	39.83	79.53	21.32	93.95	93.63
	Average, . .	89.65	35.56	80.36	48.93	95.27	93.22
Eureka silage corn stover.	Old Sheep II., .	53.53	46.13	49.67	56.18	52.86	66.18
	Old Sheep III., .	55.27	43.88	46.91	61.94	52.99	66.98
	Average, . .	54.40	45.01	48.29	59.06	52.93	66.58
Pride of the North corn stover.	Old Sheep II., .	52.87	32.82	44.57	57.89	53.08	63.05
	Old Sheep III., .	55.06	29.36	45.12	62.60	54.68	65.75
	Average, . .	53.97	31.09	44.85	60.25	53.88	64.40
English hay, .	Paige Sheep IV.,	57.54	36.96	50.89	59.76	60.88	50.81
	Paige Sheep V., .	58.41	44.07	56.33	58.36	61.94	44.70
	Average, . .	57.98	40.52	53.61	59.36	61.44	47.76
English hay, .	Young Sheep I., .	55.98	42.98	48.09	56.09	59.91	49.46
	Young Sheep II.,	59.03	43.77	47.36	61.21	62.65	52.80
	Young Sheep III.,	56.21	44.17	46.65	55.35	60.78	52.86
	Average, . .	57.07	43.64	47.37	57.55	61.11	51.71
English hay, .	Old Sheep II., .	61.72	47.36	55.54	64.52	64.01	50.45
	Old Sheep III., .	59.74	43.67	51.87	63.09	62.18	50.08
	Average, . .	60.73	45.52	53.71	63.81	63.10	50.27

Discussion of the Results.

The most important results obtained from the experiments reported in the previous pages are discussed under the following headings: —

Soy Bean Fodder (*Brook's Medium Green*). — This fodder was grown upon a twentieth-acre plat which had produced soy beans for two years previously. The crop was fertilized in the same way as that used in a digestion trial the previous year, and yielded at the rate of 6 tons to the acre. The fodder was cut from time to time as needed during the first fourteen days of September, the period proper lasting from the 8th to the 14th. The plants were fully podded and the beans quite well developed, but the foliage was still green. In common with other legumes at a similar stage of growth, the soy bean fodder showed a high protein percentage, and moderate percentages of fiber and extract matter.

Summary of Digestion Coefficients (*Per Cent.*).

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Young Sheep I., . . .	–	1	68.77	45.20	81.30	53.37	78.47	69.31
Young Sheep II., . . .	–	1	64.09	38.95	79.61	46.63	73.91	65.38
Young Sheep III., . . .	–	1	61.61	33.72	79.88	42.65	71.44	67.80
Average (1904), ...	1	3	64.82	39.29	80.26	47.55	74.61	67.50
Average (1903), ...	1	3	63.53	21.05	82.96	38.90	77.82	65.42
Average, both trials, . .	2	6	64.17	30.17	81.61	43.42	76.22	66.46
Average, all trials seeding, .	4	12	65.00	28.00	78.00	45.00	77.00	55.00
Clover for comparison, . .	3	7	66.00	–	70.00	54.00	72.00	64.00
Cowpea fodder for comparison,	2	4	68.00	23.00	76.00	60.00	81.00	59.00

The 1904 trial was made with one lot of sheep, and the 1903 trial with another. The results of both trials agree as closely as could be expected. The soy bean fodder appears to be slightly less digestible than that of other legumes, due in all probability to the tough, woody stems which are characteristic of the plant. Note the low digestibility of the fiber and the high digestibility of the protein.

Blomo Feed. — This feed, put out by the Blomo Manufacturing Company of New York, consisted of a fibrous material resembling ground corn stalks or cut hay, together with fresh blood and molasses. It was quite dark in color, coarse in appearance and rather sticky to the touch. Many samples contained an excess of moisture, which caused it to spoil during the warm season. The sample under examination contained, in dry matter, some 17 per cent. protein, 13 per cent. fiber and only a trace of fat.

Summary of Digestion Coefficients (Per Cent.).

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Old Sheep II.,	1	1	64.02	31.20	64.48	50.81	73.20	13.79
Old Sheep III.,	1	1	69.46	31.62	60.98	71.89	78.70	16.75
Average,	1	2	66.74	31.41	62.73	61.35	75.95	15.27
Oats for comparison,	3	13	71.00	–	80.00	30.00	76.00	83.00
Rowen for comparison,	4	16	64.00	–	69.00	66.00	64.00	47.00

The parallel tests do not agree quite as closely as one could wish, the cause of the disagreement being due primarily to the fact that Sheep II. was not able to digest the fiber as fully as Sheep III. The percentage of fat is so small (less than 1 per cent.) that its digestibility is of minor consequence. It is understood that the Blomo feed was intended to be used chiefly as an oat substitute for horses. A comparison of the digestion coefficients of the two feeds proves the Blomo to be not quite as fully digested as the oats. The advantages, therefore, if any, of the Blomo feed would be due to the favorable effect of the molasses, and in its furnishing a change from the regular corn and oat diet. At the price asked Blomo could not be considered an economical feed for dairy stock. Its digestion coefficients do not vary greatly from those of a good quality of rowen, and it is doubtful if it would produce any more favorable results.

Malt Sprouts. — The sprouts were of good color, and contained nearly 29 per cent. of crude protein, 33.47 per cent. of which was in the amido form.

Summary of Digestion Coefficients (Per Cent.).

Period III.

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Young Sheep I., . . .	1	1	89.03	33.30	77.23	100+	91.35	85.38
Young Sheep II., . . .	1	1	75.13[1]	2.87	73.87	100.00	77.56	74.42
Young Sheep III., . . .	1	1	81.45	21.18	76.67	98.26	86.99	100.00
Average, ...	1	3	81.87	19.12	75.92	99.42	85.30	86.60
Average, all trials, made in Massachusetts.	2	4	81.00	19.00	76.00	100.00	83.00	80.00
German trials,[2]	6	12	72.00[3]	–	80.00	55.00	73.00	71.00

The results with the three sheep show wide variations, especially in case of the total dry matter, ash and extract matter, and it is evident that difficulty was experienced in digesting the sprouts. Similar results were experienced in a previous trial,[4] two sheep digesting but 60 per cent. of the dry matter and a third 78 per cent. The results secured with the two former sheep were discarded. The high fiber coefficients in the present experiment indicate that the addition of the nitrogenous sprouts increased the digestibility of the hay fiber.

The results of German experiments likewise show especially wide variations in the digestibility of the organic matter, fiber and extract matter. The latter experiments do not show as high an average digestibility for fiber as do our own trials. It seems probable that these differences may be due largely to the character of the sprouts employed. Böhmer[5] states that light-colored sprouts show a higher degree of digestibility than dark-brown sprouts derived from slightly scorched malt. Kellner[6] has shown that, while the organic matter of the sprouts has a reasonably high digestibility because of the presence of considerable quantities of amids, cane sugar and organic acids, a definite amount does not have as great a feeding effect as does a like amount contained in the cereals.

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[1] The fæces from Sheep II. were somewhat soft for a few days during the collection, which was an evidence of indigestion.

[2] Kellner's Die Ernährung der Landw. Nutzthiere, page 570.

[3] Organic matter.

[4] See sixteenth report of this station, page 77.

[5] Kraftfuttermittel, page 206.

[6] *Loco citato*, pages 160, 357.

Sucrene Dairy Feed. — This is one of the so-called sugar feeds, consisting of wheat, corn, oats and barley products (or by-products), light oats, cotton-seed meal or other protein concentrate, and one-fourth to one-third molasses. The sample tested contained (in dry matter) 18.48 per cent. protein and 14.11 per cent. fiber.

Summary of Digestion Coefficients (Per Cent.).

Period IX.

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Old Sheep II., ...	1	1	71.58	47.51	64.45	70.41	74.57	96.06
Old Sheep III., ...	1	1	67.38	27.92	57.12	73.46	70.50	92.75
Average, ...	1	2	69.48	37.72	60.79	71.94	72.54	94.41
Wheat bran for comparison, .	8	18	62.00	–	77.00	21.00	69.00	66.00
Flour middlings for comparison.	1	2	83.00	–	85.00	36.00	88.00	85.00
Gluten feed for comparison, .	5	11	85.00	–	85.00	76.00	89.00	83.00

The sugar feed may be said to be but moderately digestible. In total dry matter it is rather more digestible than bran, but the protein in the latter has noticeably higher digestion coefficients. It is decidedly less digestible than either flour middlings or gluten feed, and either of the two latter feeds would furnish digestible matter and especially digestible protein for less money than the Sucrene feed.

Holstein Sugar Feed. — This feed appeared to be a mixture of cereal products or by-products, molasses and some cotton-seed meal. It contained rather less water than the Sucrene, but was coarser and rather more sticky to handle.

Summary of Digestion Coefficients (Per Cent.).

Period X.

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Young Sheep I., ...	1	1	70.16	24.08	61.22	44.28	80.61	88.49
Young Sheep II., ...	1	1	74.13	31.74	64.90	62.30	82.04	88.61
Young Sheep III., ...	1	1	69.63	43.08	70.83	25.64	78.85	86.39
Average, ...	1	3	71.31	32.97	65.65	44.07	80.50	87.83

The dry matter of the Holstein feed was about as digestible as that contained in the Sucrene feed. Its fiber was rather less digestible and its extract matter had a higher digestibility than that contained in the latter feed.

Macon Sugar Feed. — This feed was furnished by Chapin & Co., and shipped from St. Louis. In appearance it quite closely resembled the Sucrene feed. The sample contained rather less protein and fiber and noticeably more extract matter than the Sucrene.

Summary of Digestion Coefficients (Per Cent.).

Period XI.

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Old Sheep II., ...	1	1	69.03	20.52	60.50	36.40	80.83	74.07
Old Sheep III., ...	1	1	72.03	20.31	57.26	51.35	83.41	90.66
Average, ...	1	2	70.53	20.42	58.88	43.88	82.12	82.37

The results secured with the Macon feed do not vary materially from those obtained with the Sucrene and Holstein feeds. The fiber in the Macon is rather less and the extract matter more digestible than that contained in the Sucrene. In general it may be said that the digestibility of the three sugar feeds resembles each other quite closely.[1]

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[1] The economic value of these feeds will be more fully discussed in a future bulletin on the value of molasses and molasses feeds.

Eureka Silage Corn Stover. — This was derived from Eureka corn [1] grown on an experiment plat of the station during 1904, and cured in the stock out of doors. The corn was cut September 15, the ears at the time being only partially developed (kernels forming). The digestion experiment was made with the entire plant, minus the ears. In spite of the fact that the corn was well cured, it contained 62.89 per cent. water.

Pride of the North Corn Stover. — This corn was grown the same season, on a plat near by the Eureka, and received the same treatment. It was fairly well eared. The digestion test was made with the entire plant, minus the ears.

Summary of Digestion Coefficients (Per Cent.).

Periods V and VII.

		Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Eureka.	Old Sheep II., . . .	1	1	53.53	46.13	49.67	56.18	52.86	66.18
	Old Sheep III., . .	1	1	55.27	43.88	46.91	61.94	52.99	66.98
	Average, . . .	1	2	54.40	45.01	48.29	59.06	52.93	66.58
Pride of the North.	Old Sheep II., . . .	1	1	52.87	32.82	44.57	57.89	53.08	63.05
	Old Sheep III., . .	1	1	55.06	29.36	45.12	62.60	54.68	65.75
	Average, . . .	1	2	53.97	31.09	44.85	60.25	53.88	64.40
Average, all trials, for corn stover.		11	31	57.00	41.00	36.00	64.00	59.00	70.00

Both varieties of corn stover were equally well digested. The digestion coefficients are slightly lower than the average results of all trials.

English Hay. — This hay consisted largely of Kentucky blue grass (*Poa pratensis*), with an admixture of timothy, sweet vernal grass and red clover. It was cut June 20, when the blue grass and clover were in blossom, and carefully cured. The hay was used in connection with the several experiments reported in this series.

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[1] See eighteenth report of this station, pages 86–93.

Summary of Coefficients (Per Cent.).

Periods.		Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
VI.,	Paige Sheep IV., .	1	1	57.54	36.96	50.89	59.76	60.88	50.81
	Paige Sheep V., .	1	1	58.41	44.07	56.33	58.36	61.94	44.70
	Average, . .	1	2	57.98	40.52	53.61	59.06	61.44	47.76
IX.,	Old Sheep II., . .	1	1	61.72	47.36	55.54	64.52	64.01	50.45
	Old Sheep III., . .	1	1	59.74	43.67	51.87	63.09	62.18	50.08
	Average, . .	1	2	60.72	45.50	53.69	63.79	63.08	50.24
VIII.,	Young Sheep I., .	1	1	55.98	42.98	48.09	56.09	59.91	49.46
	Young Sheep II., .	1	1	59.03	43.77	47.36	61.21	62.65	52.80
	Young Sheep III., .	1	1	56.21	44.17	46.65	55.35	60.78	52.86
	Average, . .	1	3	57.07	43.64	47.37	57.55	61.11	51.71
	Average, all sheep, .	1	7	58.38	43.28	50.96	59.76	61.77	50.16
	Average, all previous trials.	15	60	60.00	47.00	57.00	60.00	61.00	50.00
	Average, timothy hay.	24	58	55.00	39.00	48.00	50.00	62.00	50.00

The so-called "Old Sheep" gave slightly higher coefficients than the other two lots. The former are some six years and the latter four years old. This difference in ability to digest, especially between the old and young sheep, has been noticed repeatedly. The hay gave about the same digestion coefficients as those secured with similar lots in previous trials. Hay of this character, designated "cow hay" by farmers, tests higher in protein, is rather more digestible, and probably requires less energy for its digestion than timothy hay.

Hominy Feed. — This material consisted of the hull, germ and some of the gluten and starch of the Indian corn. The sample appeared to be of good average quality.

Summary of Digestion Coefficients (Per Cent.).

Period XII.

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep IV.,	1	1	89.26	37.38	67.23	97.43	94.42	88.62
Paige Sheep V.,	1	1	85.90	60.37	71.85	62.49	90.79	87.70
Average,	1	2	87.58	48.88	69.54	79.96	92.61	88.16
Average, 1903,[1]	1	3	80.75	22.74	67.48	–	85.97	91.61
Average, 1904,[1]	1	3	79.42	38.26	58.07	38.12	87.66	94.09
Average, all trials,	3	8	81.96	35.10	64.47	79.96	88.26	91.68
Corn meal for comparison,	–	–	89.00	–	70.00	–	94.00	91.00

[1] Seventeenth report of this station, page 75.

The results of the two trials in the present experiment agree fairly well one with the other, and the average of the two are nearly equal to the coefficients for corn meal. The coefficients secured with the several sheep in the two previous experiments (1903 and 1904) showed marked differences. While these variations may have been due partially to the quality of the two different lots of hominy (which, however, could not be detected by chemical analysis), it seems probable that the chief cause for the lack of agreement is to be found in the sheep themselves. The writer has frequently noticed that after sheep have been used in digestion work for a number of months their power to digest becomes temporarily weakened. This condition is more noticeable with some sheep than with others, and evidently depends largely upon individuality. The digestion coefficients for hominy secured with the Old Sheep (1903) were obtained in one of a series of experiments extending from the autumn of 1902 to March 1903. The hominy meal period was the last of the series, and the digestibility of the dry matter varied from 71 to 91 per cent. The coefficients reported with the Young Sheep (1904) (75 to 86 per cent. of dry matter digestible) were obtained in a series extending from the autumn of 1903 to the spring of 1904. These sheep were used for the first time in this series, and were alternated to an extent with the Old

Sheep. The hominy feed was used in the last of four experiments made with these sheep during the series. While the latter results agree better than those secured with the Old Sheep, they were not as satisfactory as could be desired.

The average of all trials show the dry matter to be 82 per cent. digestible. It is believed, however, that the coefficients secured with the Paige Sheep (fully reported in the present trial) more closely represent the digestibility of the best grades of hominy feed. Allowing hominy feed to contain 91 per cent. and corn meal 86 per cent. of dry matter, and applying the average digestion coefficients secured for hominy and corn meal, the former would contain 1,492 pounds and the latter 1,541 pounds digestible dry matter in one ton. By using the coefficients secured with the Paige Sheep, the hominy is shown to contain 1,565 pounds of digestible dry matter in a ton. It may therefore safely be assumed that a ton of standard hominy feed has fully as much digestible matter as is contained in a like quantity of an average quality of corn meal. Hominy contains rather more protein and noticeably more fat than clear corn, and for some purposes may be considered a preferable feed.

Oat Middlings, occasionally found upon the market, is presumably the fine residue from the oatmeal factories. It contains but a few per cent. of fiber, about 9 per cent. of water, 16 per cent. of protein and 6 per cent. of fat.

Summary of Digestion Coefficients (Per Cent.).

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep I., ...	1	1	91.27	31.28	81.18	76.54	96.58	92.81
Paige Sheep II., ...	1	1	88.02	39.83	79.53	21.32	93.95	93.63
Average, ...	1	2	89.65	35.56	80.36	48.93	95.27	93.22
Average fine wheat middlings for comparison.	2	4	82.00	–	88.00	36.00	88.00	86.00

The oat middlings are shown to be quite thoroughly digested, especially the starchy matter and fat; the protein had also a relatively high digestibility. The small amount of fiber present renders its degree of digestibility comparatively unimportant. Judged from composition and digestibility, this oat by-product would be a few per cent. more valuable than average wheat flour middlings for ordinary feeding purposes. It ought to make a valuable feed for young calves.

Buckwheat Middlings. — This material is the residue from small mills which prepare buckwheat flour for human use. It consisted of the middlings and a small portion of the bran. Genuine buckwheat middlings should contain 25 per cent. of protein, 7 per cent. of fat and not over 10 per cent. of fiber. Samples found in the market known as buckwheat feed frequently show a considerable admixture of the bran and analyze as high as 25 per cent. of fiber. Buckwheat bran is very indigestible, and consequently such material is quite inferior in feeding value to the straight middlings.

Summary of Digestion Coefficients (Per Cent.).

Period XIII.

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Young Sheep I., . . .	1	1	75.14	25.80	86.04	7.74	83.56	88.31
Young Sheep II., . . .	1	1	78.72	41.35	83.03	26.11	87.00	92.30
Young Sheep III., . . .	1	1	71.27	39.52	86.31	–	79.24	87.47
Average, ...	1	3	75.04	35.56	85.13	16.92[1]	83.27	89.36
Gluten feed for comparison, .	7	13	86.00	–	85.00	76.00	89.00	83.00

Sheep III. did not digest the middlings quite as well as the other two sheep. The material, as is shown by the coefficients obtained for the dry matter, appeared to be fairly well digested, although not as fully as the easily digested gluten feed. The protein had a high digestibility, being equal to other high-grade protein concentrates. It is evident from the analysis, from the digestion coefficients obtained and from the retail price of the article ($26 to $28 a ton) that genuine buckwheat middlings is an economical source of dry matter and digestible protein.[1]

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[1] Average, two trials.

[2] It is not advisable to feed over 3 pounds of this material daily to mature dairy stock; larger quantities are likely to cause illness.

SERIES XI.

This series was begun August 12, 1905, with Early Amber Sorghum, and continued until April 7, 1906. The Paige Sheep worked especially well in this series, and were used in the larger number of the experiments. The digestion hay used in periods III. and IV. was the new hay described in the previous series, to which the reader is referred for composition and digestion coefficients. The composition of the hay used in all other periods is given in the table of analyses. The coefficients employed were the following: —

	Old Sheep II. and III.	Young Sheep I., II. and III.	Paige Sheep IV. and V.
Dry matter,	67.87	65.92	65.48
Ash,	49.17	51.95	44.60
Protein,	62.31	61.98	61.53
Fiber,	76.30	72.87	73.81
Nitrogen-free extract,	66.39	64.66	64.46
Fat,	52.37	54.23	50.20

Composition of Feed Stuffs (Per Cent.).

[Dry Matter.]

FEEDS.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
English hay (used in 1904–05 experiments),	8.20	8.69	32.14	48.56	2.41
Early Amber Sorghum fodder,	6.06	6.24	29.28	56.00	2.42
Pride of the North corn fodder,	5.56	8.83	23.11	60.24	2.26
Porto Rico molasses,	8.45	3.94	–	87.61	–
English hay (new lot, 1905–06),	6.75	12.23	33.45	44.67	2.90
Gluten feed,	1.67	24.98	7.22	63.34	2.79
Porto Rico molasses,	9.22	3.94	–	86.84	–
Green Diamond sugar feed,	9.88	13.71	15.27	58.47	2.67
Sea Island cotton-seed meal,	5.20	27.31	19.67	41.47	6.35
Red wheat meal,	1.92	9.96	2.99	82.83	2.80
Leaming corn silage,	6.07	10.19	26.06	54.89	2.79
White winter wheat meal,	1.90	13.07	2.38	80.49	2.16
Feed barley (ground),	3.27	14.60	6.19	73.90	2.04

Composition of Fæces (Per Cent.).

[Dry Matter.]

Periods.	Feeds.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
	Young Sheep I.					
IX.,	English hay (1905–06),	9.82	13.27	26.90	46.01	4.00
XII.,	Red wheat meal,	9.91	15.66	24.82	45.61	4.00
XV.,	White winter wheat,	10.39	14.70	24.51	46.02	4.38
	Young Sheep II.					
IX.,	English hay (1905–06),	9.68	14.55	25.28	46.62	3.87
XV.,	White winter wheat,	11.60	15.20	24.26	45.16	3.78
	Young Sheep III.					
IX.,	English hay (1905–06),	9.07	13.14	27.65	46.32	3.82
XII.,	Red wheat meal,	9.24	15.08	25.85	46.02	3.81
XV.,	White winter wheat,	9.15	14.24	26.30	46.23	4.08
	Old Sheep II.					
II.,	Pride of the North corn fodder,	11.86	11.17	27.55	47.68	1.74
VI.,	English hay (1905–06),	10.80	14.70	23.99	46.27	4.24
XIII.,	Leaming corn silage,	10.48	13.70	25.15	47.75	2.92
	Old Sheep III.					
II.,	Pride of the North corn fodder,	12.86	11.18	27.68	46.35	1.93
VI.,	English hay (1905–06),	10.57	14.03	25.31	45.74	4.35
X.,	Green Diamond sugar feed,	14.70	13.68	24.47	44.42	2.73
XIII.,	Leaming corn silage,	10.39	13.02	25.14	48.47	2.98
	Paige Sheep IV.					
I.,	Early Amber Sorghum,	11.28	11.13	27.02	47.44	3.13
III.,	Porto Rico molasses,	12.16	10.72	29.32	44.87	2.93
IV.,	Porto Rico molasses,	13.66	11.47	27.13	44.86	2.88
V.,	English hay (1905–06),	11.18	14.10	24.20	46.24	4.28
VII.,	Gluten feed,	10.55	15.33	22.35	47.20	4.57
VIII.,	Gluten feed and molasses,	11.15	16.36	21.26	47.44	3.79
XI.,	Sea Island cotton-seed meal,	8.67	14.17	32.75	41.31	3.10
XIV.,	Green Diamond sugar feed,	13.02	12.79	25.41	45.59	3.19
XVI.,	Feed barley,	12.50	13.86	23.08	46.46	4.10

Composition of Fæces — Concluded.

[Dry Matter.]

Paige Sheep V.

Periods.	FEEDS.	Ash.	Protein.	Fiber.	Nitrogen-free Extract Matter.	Fat.
I.,	Early Amber Sorghum, . . .	11.06	9.39	31.21	45.75	2.59
III.,	Porto Rico molasses, ...	11.83	10.53	30.33	44.47	2.84
IV.,	Porto Rico molasses, ...	12.87	11.49	28.95	43.94	2.75
V.,	English hay (1905–06), . . .	10.49	13.17	26.51	45.74	4.09
VII.,	Gluten feed, ...	10.63	15.05	22.84	46.84	4.64
VIII.,	Gluten feed and molasses, . . .	10.82	16.21	22.09	47.15	3.73
XI.,	Sea Island cotton-seed meal, . .	9.33	15.20	29.46	42.86	3.15
XVI.,	Feed barley, ...	11.14	13.86	25.39	45.75	3.86

Dry Matter Determinations made at the Time of weighing out the Different Foods, and Dry Matter in Air-dry Fæces (Per Cent.).

Paige Sheep IV.

PERIODS.	English Hay.	Early Amber Sorghum.	Porto Rico Molasses.	Gluten Feed.	Sea Island Cotton-seed Meal.	Green Diamond Sugar Feed.	Feed Barley.	Fæces.
I.,	–	16.35	–	–	–	–	–	87.84
III.,	88.15	–	71.49	–	–	–	–	92.84
IV.,	87.22	–	72.12	–	–	–	–	92.33
V.,	88.65	–	–	–	–	–	–	92.22
VII.,	88.55	–	–	90.03	–	–	–	93.47
VIII.,	88.92	–	72.67	92.02	–	–	–	92.50
XI.,	90.92	–	–	–	90.97	–	–	93.16
XIV.,	90.17	–	–	–	–	89.62	–	94.42
XVI.,	89.35	–	–	–	–	–	89.07	92.96

Paige Sheep V.

I.,	–	16.35	–	–	–	–	–	87.69
III.,	88.15	–	71.49	–	–	–	–	93.14
IV.,	87.22	–	72.12	–	–	–	–	92.16
V.,	88.65	–	–	–	–	–	–	92.14
VII.,	88.55	–	–	90.03	–	–	–	93.61
VIII.,	88.92	–	72.67	92.02	–	–	–	92.36
XI.,	90.92	–	–	–	90.97	–	–	92.98
XVI.,	89.35	–	–	–	–	–	89.07	92.80

Dry Matter Determinations, etc. — Concluded..

Young Sheep I.

Periods.	English Hay.	Pride of the North Corn Fodder.	Green Diamond Sugar Feed.	Red Wheat Meal.	Leaming Corn Silage.	White Wheat Meal.	Fæces.
IX., . . .	90.35	-	-	-	-	-	94.99
XII., . . .	88.92	-	-	87.43	-	-	94.25
XV., . . .	89.60	-	-	-	-	87.80	93.27

Young Sheep II.

IX., . . .	90.35	-	-	-	-	-	94.72
XV., . . .	89.60	-	-	-	-	87.80	92.91

Young Sheep III.

IX., . . .	90.35	-	-	-	-	-	94.86
XII., . . .	88.92	-	-	87.43	-	-	94.17
XV., . . .	89.60	-	-	-	-	87.80	93.09

Old Sheep II.

II., . . .	-	22.61	-	-	-	-	89.28
VI., . . .	88.97	-	-	-	-	-	93.54
XIII., . . .	90.17	-	-	-	21.44	-	94.12

Old Sheep III.

II., . . .	-	22.61	-	-	-	-	89.09
VI., . . .	88.97	-	-	-	-	-	93.52
X., . . .	88.95	-	91.95	-	-	-	94.09
XIII., . . .	90.17	-	-	-	21.44	-	94.19

Average Daily Amount of Manure excreted and Water drank (Grams).

Paige Sheep IV.

Periods.	Character of Food or Ration.	Manure excreted daily.	One-tenth Manure Air Dry.	Water drank daily.
I.,	Early Amber Sorghum, ...	500	41.06[1]	49
III.,	Hay and Porto Rico molasses, . . .	674	31.10	1,725
IV.,	Hay and Porto Rico molasses, . . .	738	33.34	2,114
V.,	English hay, ...	610	26.11	1,781
VII.,	Hay and gluten feed, ...	460	20.82	1,498
VIII.,	Hay, gluten feed and molasses, . . .	635	25.84	1,843
XI.,	Hay and Sea Island cotton-seed meal, . .	607	29.67	2,095
XIV.,	Hay and Green Diamond sugar feed, . .	598	27.45	2,241
XVI.,	Hay and feed barley, ...	478	20.32	1,644

[1] One-fifth of daily amount excreted.

Average Daily Amount of Manure excreted and Water drank (Grams) — Concluded.

Paige Sheep V.

Periods.	CHARACTER OF FOOD OR RATION.	Manure excreted daily.	One-tenth Manure Air Dry.	Water drank daily.
I.,	Early Amber Sorghum,	591	43.80[1]	55
III.,	Hay and Porto Rico molasses,	745	32.86	1,995
IV.,	Hay and Porto Rico molasses,	855	34.12	2,014
V.,	English hay,	623	27.02	1,642
VII.,	Hay and gluten feed,	459	20.01	1,318
VIII.,	Hay, gluten feed and molasses,	655	25.86	1,953
XI.,	Hay and Sea Island cotton-seed meal,	673	26.70	2,138
XIV.,	Hay and Green Diamond sugar feed,	–	–	–
XVI.,	Hay and feed barley,	705	21.50	1,644

[1] One-fifth of daily amount excreted.

Young Sheep I.

Periods.	CHARACTER OF FOOD OR RATION.	Manure excreted daily.	One-tenth Manure Air Dry.	Water drank daily.
IX.,	English hay (new lot),	635	27.46	2,170
XII.,	Hay and red wheat meal,	557	20.98	2,025
XV.,	Hay and white winter wheat,	488	21.86	2,038

Young Sheep II.

Periods.	CHARACTER OF FOOD OR RATION.	Manure excreted daily.	One-tenth Manure Air Dry.	Water drank daily.
IX.,	English hay (new lot),	779	26.96	2,341
XII.,	Hay and red wheat meal,	–	–	–
XV.,	Hay and white winter wheat,	1,077	24.15	2,338

Young Sheep III.

Periods.	CHARACTER OF FOOD OR RATION.	Manure excreted daily.	One-tenth Manure Air Dry.	Water drank daily.
IX.,	English hay (new lot),	695	28.35	2,495
XII.,	Hay and red wheat meal,	617	22.32	2,352
XV.,	Hay and white winter wheat,	537	22.99	2,495

Old Sheep II.

Periods.	CHARACTER OF FOOD OR RATION.	Manure excreted daily.	One-tenth Manure Air Dry.	Water drank daily.
II.,	Pride of the North corn fodder,	624	25.62	80
VI.,	English hay (1905–06),	613	26.21	1,694
X.,	Hay and Green Diamond sugar feed,	–	–	–
XIII.,	Hay and Leaming corn silage,	747	24.04	1,974

Old Sheep III.

Periods.	CHARACTER OF FOOD OR RATION.	Manure excreted daily.	One-tenth Manure Air Dry.	Water drank daily.
II.,	Pride of the North corn fodder,	820	28.12	60
VI.,	English hay (1905–06),	608	28.80	1,544
X.,	Hay and Green Diamond sugar feed,	676	27.08	2,329
XIII.,	Hay and Leaming corn silage,	537	22.42	1,309

Weights of Animals at Beginning and End of Period (Pounds).

Paige Sheep IV.

Periods.	CHARACTER OF FOOD OR RATION.	Beginning.	End.
I.,	Early Amber Sorghum,	147.00	146.50
III.,	Hay and Porto Rico molasses,	144.00	142.00
IV.,	Hay and Porto Rico molasses,	145.50	150.00
V.,	English hay,	142.00	144.00
VII.,	Hay and gluten feed,	141.50	141.00
VIII.,	Hay, gluten feed and molasses,	145.00	142.00
XI.,	Hay and Sea Island cotton-seed meal,	144.00	145.00
XIV.,	Hay and Green Diamond sugar feed,	145.50	148.50
XVI.,	Hay and feed barley,	148.00	143.50

Paige Sheep V.

Periods.	CHARACTER OF FOOD OR RATION.	Beginning.	End.
I.,	Early Amber Sorghum,	124.25	126.00
III.,	Hay and Porto Rico molasses,	124.00	122.00
IV.,	Hay and Porto Rico molasses,	122.50	125.50
V.,	English hay,	122.00	121.50
VII.,	Hay and gluten feed,	118.50	120.00
VIII.,	Hay, gluten feed and molasses,	125.50	122.50
XI.,	Hay and Sea Island cotton-seed meal,	124.50	123.50
XIV.,	Hay and Green Diamond sugar feed,	-	-
XVI.,	Hay and feed barley,	124.50	117.00

Young Sheep I.

Periods.	CHARACTER OF FOOD OR RATION.	Beginning.	End.
IX.,	English hay (1905–06),	121.00	119.00
XII.,	Hay and red wheat meal,	118.00	117.00
XV.,	Hay and white winter wheat,	119.50	118.00

Young Sheep II.

Periods.	CHARACTER OF FOOD OR RATION.	Beginning.	End.
IX.,	English hay (1905–06),	111.00	113.00
XII.,	Hay and red wheat meal,	-	-
XV.,	Hay and white winter wheat,	-	-

Young Sheep III.

Periods.	CHARACTER OF FOOD OR RATION.	Beginning.	End.
IX.,	English hay (1905–06),	113.00	110.00
XII.,	Hay and red wheat meal,	109.00	109.00
XV.,	Hay and white winter wheat,	110.00	108.50

Weights of Animals at Beginning and End of Period (Pounds) — Concluded.

Old Sheep II.

Periods.	Character of Food or Ration.	Beginning.	End.
II.,	Pride of the North corn fodder, ...	160.00	154.00
VI.,	English hay (1905–06), ...	154.00	150.00
X.,	Hay and Green Diamond sugar feed, . . .	–	–
XIII.,	Hay and Leaming corn silage, ...	154.50	155.00

Old Sheep III.

II.,	Pride of the North corn fodder, ...	151.50	150.00
VI.,	English hay (1905–06), ...	146.50	145.00
X.,	Hay and Green Diamond sugar feed, . . .	145.00	147.50
XIII.,	Hay and Leaming corn silage, ...	152.00	152.00

Early Amber Sorghum. — Period I.

Paige Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
3,600 grams Sorghum fodder fed, .	588.60	35.67	36.73	172.34	329.62	14.24
205.30 grams manure excreted, . .	180.34	20.34	20.07	48.73	85.55	5.64
Grams digested, ...	408.26	15.33	16.66	123.61	244.07	8.60
Per cent. digested, ...	69.36	42.98	45.36	71.72	74.04	60.39

Paige Sheep V.

3,600 grams Sorghum fodder fed, .	588.60	35.67	36.73	172.34	329.62	14.24
219 grams manure excreted, . . .	192.04	21.24	18.03	59.94	87.86	4.97
Grams digested, ...	396.56	14.43	18.70	112.40	241.76	9.27
Per cent. digested, ...	67.37	40.45	50.91	65.22	73.35	65.10
Average per cent. for both sheep, .	68.37	41.72	48.14	68.47	73.70	62.75

Average nutritive ratio of rations for two sheep, 1:21.5.

Pride of the North Corn Fodder. — Period II.

Old Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
3,600 grams Pride of the North corn fodder fed.	813.96	45.26	71.87	188.11	490.33	18.40
256.23 grams manure excreted, . .	228.76	27.13	25.55	63.02	109.07	3.98
Grams digested, ...	585.20	18.13	46.32	125.09	381.26	14.42
Per cent. digested, ...	71.89	40.06	64.45	66.50	77.76	78.37
Old Sheep III.						
3,600 grams Pride of the North corn fodder fed.	813.96	45.26	71.87	188.11	490.33	18.40
281.19 grams manure excreted, . .	250.51	32.22	28.01	69.34	116.11	4.83
Grams digested, ...	563.45	13.04	43.86	118.77	374.22	13.57
Per cent. digested, ...	69.22	28.81	61.03	63.14	76.32	73.75
Average per cent. for both sheep, .	70.56	34.43	62.74	64.82	77.04	76.06

Average nutritive ratio of rations for two sheep, 1:11.8.

Porto Rico Molasses. — Period III.

Paige Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed, . . .	705.20	57.83	61.28	226.65	342.45	17.00
150 grams molasses fed, ...	107.24	9.06	4.23	–	93.95	–
Amount consumed, ...	812.44	66.89	65.51	226.65	436.40	17.00
311 grams manure excreted, . . .	288.73	35.11	30.95	84.66	129.55	8.46
Grams digested, ...	523.71	31.78	34.56	141.89	306.85	8.54
Minus hay digested, ...	408.87	23.43	32.85	133.86	210.30	8.12
Molasses digested, ...	114.84	8.35	1.71	8.03	96.55	.42
Per cent. digested, ...	107.09	92.16	40.43	–	102.76	–
Paige Sheep V.						
Amount consumed as above, . .	812.44	66.89	65.51	226.65	436.40	17.00
328.60 grams manure excreted, . .	306.06	36.21	32.23	92.83	136.10	8.69
Grams digested, ...	506.38	30.68	33.28	133.82	300.30	8.31
Minus hay digested, ...	408.87	23.43	32.85	133.86	210.30	8.12
Molasses digested, ...	97.51	7.25	.43	–	90.00	.19
Per cent. digested, ...	90.93	80.02	10.17	–	95.80	–
Average per cent. for both sheep, .	99.01	86.09	25.30	–	99.28	–

Average nutritive ratio of rations for two sheep, 1: 13.6.

Porto Rico Molasses. — Period IV.

Paige Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed, ...	697.76	57.22	60.64	224.26	338.82	16.82
250 grams molasses fed, ...	180.30	15.24	7.10	–	157.96	–
Amount consumed, ...	878.06	72.46	67.74	224.26	496.78	16.82
333.40 grams manure excreted, . .	307.83	42.05	35.31	83.51	138.09	8.87
Grams digested, ...	570.23	30.41	32.43	140.75	358.69	7.95
Minus hay digested, ...	404.56	23.19	32.51	132.44	208.07	8.03
Molasses digested, ...	165.67	7.22	—.08	8.31	150.62	–
Per cent. digested, ...	91.89	47.38	–	–	95.35	–

Paige Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . .	878.06	72.46	67.74	224.26	496.78	16.82
341.2 grams manure excreted, . .	314.45	40.47	36.13	91.03	138.17	8.65
Grams digested, ...	563.61	31.99	31.61	133.23	358.61	8.17
Minus hay digested, ...	404.56	23.19	32.51	132.44	208.07	8.03
Molasses digested, ...	159.05	8.80	.10	.79	150.54	.14
Per cent. digested, ...	88.21	57.74	–	–	95.30	–
Average per cent. for both sheep, .	90.05	52.56	–	–	95.33	–

Average nutritive ratio of rations for two sheep, 1: 16.

English Hay. — Period V.

Paige Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed, ...	709.20	47.87	86.74	237.23	316.80	20.57
261.10 grams manure excreted, . .	240.79	26.92	33.95	58.27	111.34	10.31
Grams digested, ...	468.41	20.95	52.79	178.96	205.46	10.26
Per cent. digested, ...	66.05	43.76	60.86	75.44	64.85	49.88

Paige Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay fed, ...	709.20	47.87	86.74	237.23	316.80	20.57
270.20 grams manure excreted, . .	248.96	26.12	32.79	66.00	113.87	10.18
Grams digested, ...	460.24	21.75	53.95	171.23	202.93	10.39
Per cent. digested, ...	64.90	45.44	62.20	72.18	64.06	50.51
Average per cent. for both sheep, .	65.48	44.60	61.53	73.81	64.46	50.20

Average nutritive ratio of rations for two sheep, 1: 7.5.

English Hay. — Period VI.

Old Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
900 grams English hay fed,	800.73	54.05	97.93	267.84	357.69	23.22
262.10 grams manure excreted,	245.17	26.48	36.04	58.82	113.44	10.40
Grams digested,	555.56	27.57	61.89	209.02	244.25	12.82
Per cent. digested,	69.38	51.01	63.20	78.04	68.29	55.21
Old Sheep III.						
900 grams English hay fed,	800.73	54.05	97.93	267.84	357.69	23.22
288 grams manure excreted,	269.34	28.47	37.79	68.17	123.20	11.72
Grams digested,	531.39	25.58	60.14	199.67	234.49	11.50
Per cent. digested,	66.36	47.33	61.41	74.55	65.56	49.53
Average per cent. for both sheep,	67.87	49.17	62.31	76.30	66.39	52.37

Average nutritive ratio of rations for two sheep, 1: 7.7.

Gluten Feed. — Period VII.

Paige Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed,	531.30	35.86	64.98	177.72	237.33	15.41
200 grams gluten feed fed,	180.06	3.01	44.98	13.00	114.05	5.02
Amount consumed,	711.36	38.87	109.96	190.72	351.38	20.43
208.20 grams manure excreted,	194.60	20.53	29.83	43.49	91.85	8.89
Grams digested,	516.76	18.34	80.13	147.23	259.53	11.54
Minus hay digested,	347.90	15.99	39.98	131.18	152.98	7.74
Gluten feed digested,	168.86	2.35	40.15	16.05	106.55	3.80
Per cent. digested,	93.78	78.07	89.26	123.46	93.42	75.70
Paige Sheep V.						
Amount consumed as above,	711.36	38.87	109.96	190.72	351.38	20.43
200.10 grams manure excreted,	187.31	19.91	28.19	42.78	87.74	8.69
Grams digested,	524.05	18.96	81.77	147.94	263.64	11.74
Minus hay digested,	347.90	15.99	39.98	131.18	152.98	7.74
Gluten feed digested,	176.15	2.97	41.79	16.76	110.66	4.00
Per cent. digested,	97.83	98.67	92.91	128.92	97.03	79.68
Average per cent. for both sheep,	95.81	88.37	91.09	126.19	95.23	77.69

Average nutritive ratio of rations for two sheep, 1: 5.4.

Porto Rico Molasses. — Period VIII.

Paige Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed, . . .	533.52	36.01	65.25	178.46	238.32	15.47
200 grams gluten feed fed, . . .	184.04	3.07	45.97	13.29	116.57	5.13
250 grams molasses fed, ...	181.68	16.75	7.16	–	157.77	–
Amount consumed, ...	899.24	55.83	118.38	191.75	512.66	20.60
258.40 grams manure excreted, . .	239.02	26.65	39.10	50.82	113.39	9.06
Grams digested, ...	660.22	29.18	79.28	140.93	399.27	11.54
Minus hay and gluten feed digested, .	521.24	18.44	81.05	–	262.12	–
Molasses digested, ...	138.98	10.74	–	–	137.15	–
Per cent. digested, ...	76.50	64.12	–	–	86.93	–

Paige Sheep V.

Amount consumed as above, . .	899.24	55.83	118.38	191.75	512.66	20.60
258.60 grams manure excreted, . .	238.84	25.84	38.72	52.76	112.61	8.91
Grams digested, ...	660.40	29.99	79.66	138.99	400.05	11.69
Minus hay and gluten feed digested, .	528.63	19.06	82.70	–	266.27	–
Molasses digested, ...	131.77	10.93	–	–	133.78	–
Per cent. digested, ...	72.53	65.25	–	–	84.80	–
Average per cent. for both sheep, .	74.52	64.69	–	–	85.87	–

Average nutritive ratio of rations for two sheep, 1: 7.1.

English Hay. — Period IX.

Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
850 grams English hay fed, . . .	767.98	51.84	93.92	256.89	342.96	22.27
274.60 grams manure excreted, . .	260.84	25.61	34.61	70.17	120.01	10.43
Grams digested, ...	507.14	26.23	59.31	186.72	222.95	11.84
Per cent. digested, ...	66.04	50.60	63.15	72.68	65.01	53.17

Young Sheep II.

850 grams English hay fed, . . .	767.98	51.84	93.92	256.89	342.96	22.27
269.60 grams manure excreted, . .	255.37	24.72	37.16	64.56	119.05	9.88
Grams digested, ...	512.61	27.12	56.76	192.33	223.91	12.39
Per cent. digested, ...	66.75	52.31	60.43	74.87	65.29	55.64

English Hay — Concluded.

Young Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
850 grams English hay fed, . . .	767.98	51.84	93.92	256.89	342.96	22.27
283.50 grams manure excreted, . .	268.93	24.39	35.34	74.36	124.57	10.27
Grams digested, ...	499.05	27.45	58.58	182.53	218.39	12.00
Per cent. digested, ...	64.98	52.95	62.37	71.05	63.68	53.88
Average per cent. for three sheep, .	65.92	51.95	61.98	72.87	64.66	54.23

Average nutritive ratio of rations for three sheep, 1:7.5.

Green Diamond Sugar Feed. — Periods X. and XIV.

Old Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
400 grams Green Diamond sugar feed fed.	367.80	36.34	50.43	56.16	215.05	9.82
500 grams English hay fed, . . .	444.75	30.02	54.39	148.77	198.67	12.90
Amount consumed, ...	812.55	66.36	104.82	204.93	413.72	22.72
270.80 grams manure excreted, . .	254.80	37.46	34.86	62.35	113.18	6.96
Grams digested, ...	557.75	28.90	69.96	142.58	300.54	15.76
Minus hay digested, ...	301.85	14.76	33.89	113.51	131.90	6.76
Sugar feed digested, ...	255.90	14.14	36.07	29.07	168.64	9.00
Per cent. digested, ...	69.58	38.91	71.52	51.76	78.42	91.65

Paige Sheep IV.

300 grams Green Diamond sugar feed,	268.86	26.56	36.86	41.05	157.20	7.18
500 grams English hay fed, . . .	450.85	30.43	55.14	150.81	201.39	13.07
Amount consumed, ...	719.71	56.99	92.00	191.86	358.59	20.25
274.5 grams manure excreted, . .	259.18	33.75	33.15	65.86	118.16	8.27
Grams digested, ...	460.53	23.24	58.85	126.00	240.43	11.98
Minus hay digested, ...	295.21	13.57	33.93	111.31	129.82	6.56
Sugar feed digested, ...	165.32	9.67	24.92	14.69	110.61	5.42
Per cent. digested, ...	61.49	36.41	67.61	35.79	70.36	75.49
Average per cent. for both sheep, .	65.54	37.66	69.57	43.78	74.39	83.57

Average nutritive ratio of rations for two sheep, 1:6.8.

Sea Island Cotton-seed Meal. — Period XI.

Paige Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
200 grams Sea Island cotton-seed meal fed.	181.94	9.46	49.69	35.79	75.45	11.55
650 grams English hay fed, . . .	590.98	39.89	72.28	197.68	263.99	17.14
Amount consumed, ...	772.92	49.35	121.97	233.47	339.44	28.69
296.70 grams manure excreted, . .	276.41	23.96	39.17	90.52	114.18	8.57
Grams digested, ...	496.51	25.39	82.80	142.95	225.26	20.12
Minus hay digested, ...	386.97	17.79	44.47	145.91	170.17	8.60
Cotton-seed meal digested, . . .	109.54	7.60	38.33	–	55.09	11.52
Per cent. digested, ...	60.21	80.34	77.14	–	73.02	99.74

Paige Sheep V.

Amount consumed as above, . .	772.92	49.35	121.97	233.47	339.44	28.69
267 grams manure excreted, . . .	248.23	23.16	37.73	73.13	106.39	7.82
Grams digested, ...	524.69	26.19	84.24	160.34	233.05	20.87
Minus hay digested, ...	386.97	17.79	44.47	145.91	170.17	8.60
Cotton-seed meal digested, . . .	137.72	8.40	39.77	14.43	62.88	12.27
Per cent. digested, ...	75.69	88.79	80.04	40.32	83.34	100+
Average per cent. for both sheep, .	67.95	84.56	78.39	40.32	78.18	100

Average nutritive ratio of rations for two sheep, 1:5.1.

Red Wheat Meal. — Period XII.

Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed, . . .	489.06	33.01	59.81	163.59	218.46	14.18
300 grams red wheat meal fed, . .	262.29	5.04	26.12	7.84	215.94	7.34
Amount consumed, ...	751.35	38.05	85.93	171.43	434.40	21.52
209.80 grams manure excreted, . .	197.74	19.60	30.97	49.08	90.19	7.91
Grams digested, ...	553.61	18.45	54.96	122.35	344.21	13.61
Minus hay digested, ...	322.39	17.15	37.07	119.21	141.26	7.69
Red wheat meal digested, . . .	231.22	1.30	17.89	3.14	202.95	5.92
Per cent. digested, ...	88.15	25.79	68.49	40.05	93.98	80.65

Red Wheat Meal — Concluded.

Young Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . . .	751.35	38.05	85.93	171.43	434.40	21.52
223.20 grams manure excreted, . .	210.19	19.42	31.70	54.33	96.73	8.01
Grams digested, ...	541.16	18.63	54.23	117.10	337.67	13.51
Minus hay digested, ...	322.39	17.15	37.07	119.21	141.26	7.69
Red wheat meal digested, . . .	218.77	1.48	17.16	–	196.41	5.82
Per cent. digested, ...	83.41	29.37	65.70	–	90.96	79.29
Average per cent. for both sheep, .	85.78	27.58	67.10	–	92.47	79.97

Average nutritive ratio of rations for two sheep, 1: 9.

Leaming Corn Silage. — Period XIII.

Old Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
400 grams English hay fed, . . .	360.68	24.35	44.11	120.65	161.12	10.46
1,600 grams corn silage fed, . . .	343.04	20.82	34.96	89.40	188.29	9.57
Amount consumed, ...	703.72	45.17	79.07	210.05	394.41	20.03
240.40 grams manure excreted, . .	226.26	23.71	31.00	56.90	108.04	6.61
Grams digested, ...	477.46	21.46	48.07	153.15	241.37	13.42
Minus hay digested, ...	244.79	11.97	27.48	92.06	106.97	5.48
Corn silage digested, ...	232.67	9.49	20.59	61.09	134.40	7.94
Per cent. digested, ...	67.82	45.58	58.89	68.33	71.38	82.97

Old Sheep III.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above, . .	703.72	45.17	79.07	210.05	349.41	20.03
224.20 grams manure excreted, . .	211.17	21.94	27.49	53.09	102.35	6.29
Grams digested, ...	492.55	23.23	51.58	157.96	247.06	13.74
Minus hay digested, ...	244.79	11.97	27.48	92.06	106.97	5.48
Corn silage digested, ...	247.76	11.26	24.10	65.90	140.09	8.26
Per cent. digested, ...	72.22	54.08	68.93	73.71	74.40	86.31
Average per cent. for both sheep, .	70.02	49.83	63.91	71.02	72.89	84.64

Average nutritive ratio of rations for two sheep, 1: 8.6.

White Winter Wheat Meal. — Period XV.

Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay fed, ...	537.60	36.29	65.75	179.83	240.15	15.59
250 grams wheat meal fed, ...	219.50	4.17	28.69	5.22	176.68	4.74
Amount consumed, ...	757.10	40.46	94.44	185.05	416.83	20.33
218.60 grams manure excreted, . .	203.89	21.18	29.97	49.97	93.83	8.93
Grams digested, ...	553.21	19.28	64.47	135.08	323.00	11.40
Minus hay digested, ...	354.39	18.85	40.75	131.04	155.28	8.45
Wheat meal digested, ...	198.82	.43	23.72	4.04	167.72	2.95
Per cent. digested, ...	90.58	10.31	82.68	77.39	94.93	62.24

Young Sheep III.

Amount consumed as above, . .	757.10	40.46	94.44	185.05	416.83	20.33
229.90 grams manure excreted, . .	214.01	19.58	30.48	56.28	98.94	8.73
Grams digested, ...	543.09	20.88	63.96	128.77	317.89	11.60
Minus hay digested, ...	354.39	18.85	40.75	131.04	155.28	8.45
Wheat meal digested, ...	188.70	2.03	23.21	–	162.61	3.15
Per cent. digested, ...	85.97	48.68	80.90	–	92.04	66.46
Average per cent. for both sheep, .	88.28	29.50	81.79	–	93.49	64.35

Average nutritive ratio of rations for two sheep, 1: 7.4.

Feed Barley Meal. — Period XVI.

Paige Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay fed, ...	491.43	33.17	60.10	164.38	219.52	14.25
250 grams feed barley fed, ...	222.68	7.28	32.51	13.78	164.56	4.54
Amount consumed, ...	714.11	40.45	92.61	178.16	384.08	18.79
203.20 grams manure excreted, . .	188.89	23.61	26.18	43.60	87.76	7.74
Grams digested, ...	525.22	16.84	66.43	134.56	296.32	11.05
Minus hay digested, ...	321.79	14.79	36.98	121.33	141.50	7.15
Feed barley digested, ...	203.43	2.05	29.45	13.23	154.82	3.90
Per cent. digested, ...	91.36	28.16	90.06	96.01	94.08	85.90

Feed Barley Meal — Concluded.

Paige Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Amount consumed as above,	714.11	40.45	92.61	178.16	384.08	18.79
215 grams manure excreted,	199.52	22.23	27.65	50.66	91.28	7.70
Grams digested,	514.59	18.22	64.95	127.50	292.80	11.09
Minus hay digested,	321.79	14.79	36.98	121.33	141.50	7.15
Feed barley digested,	192.80	3.43	27.97	6.17	151.30	3.94
Per cent. digested,	86.58	47.12	86.10	44.78	91.94	86.78
Average per cent. for both sheep,	88.97	37.64	88.08	70.40	93.01	86.34

Average nutritive ratio of rations for two sheep, 1:6.8.

Summary of Coefficients.

FOOD.	Sheep and Number.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Early Amber Sorghum.	Paige Sheep IV.,	69.36	42.98	45.36	71.72	74.04	60.39
	Paige Sheep V.,	67.37	40.45	50.91	65.22	73.35	65.10
	Average,	68.37	41.72	48.14	68.47	73.70	62.75
Pride of the North corn fodder.	Old Sheep II.,	71.89	40.06	64.45	66.50	77.76	78.37
	Old Sheep III.,	69.22	28.81	61.03	63.14	76.32	73.75
	Average,	70.56	34.43	62.74	64.82	77.04	76.06
Porto Rico molasses.	Paige Sheep IV.,	107.09	92.16	40.43	–	102.76	–
	Paige Sheep V.,	90.93	80.02	10.17	–	95.80	–
	Average,	99.01	86.09	25.30	–	99.28	–
Porto Rico molasses.	Paige Sheep IV.,	91.89	47.38	–	–	95.35	–
	Paige Sheep V.,	88.21	57.74	–	–	95.30	–
	Average,	90.05	52.56	–	–	95.33	–
English hay,	Paige Sheep IV.,	66.05	43.76	60.86	75.44	64.85	49.88
	Paige Sheep V.,	64.90	45.44	62.20	72.18	64.06	50.51
	Average,	65.48	44.60	61.53	73.81	64.46	50.20
English hay,	Old Sheep II.,	69.38	51.01	63.20	78.04	68.29	55.21
	Old Sheep III.,	66.36	47.33	61.41	74.55	65.56	49.53
	Average,	67.87	49.17	62.31	76.30	66.39	52.37

Summary of Coefficients — Concluded.

Food.	Sheep and Number.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Gluten feed, .	Paige Sheep IV.,	93.78	78.07	89.26	123.46	93.42	75.70
	Paige Sheep V., .	97.83	98.67	92.91	128.92	97.03	79.68
	Average, . .	95.81	88.37	91.09	126.19	95.23	77.69
Porto Rico molasses.	Paige Sheep IV.,	76.50	64.12	-	-	86.93	-
	Paige Sheep V., .	72.53	65.25	-	-	84.80	-
	Average, . .	74.52	64.69	-	-	85.87	-
English hay, .	Young Sheep I., .	66.04	50.60	63.15	72.68	65.01	53.17
	Young Sheep II.,	66.75	52.31	60.43	74.87	65.29	55.64
	Young Sheep III.,	64.98	52.95	62.37	71.05	63.68	53.88
	Average, . .	65.92	51.95	61.98	72.87	64.66	54.23
Green Diamond sugar feed.	Old Sheep III., .	69.58	38.91	71.52	51.76	78.42	91.65
	Paige Sheep IV.,	61.49	36.41	67.61	35.79	70.36	75.49
	Average, . .	65.54	37.66	69.57	43.78	74.39	83.57
Sea Island cotton-seed meal.	Paige Sheep IV.,	60.21	80.34	77.14	-	73.02	99.74
	Paige Sheep V., .	75.69	88.79	80.04	40.32	83.34	100+
	Average, . .	67.95	84.56	78.39	40.32	78.18	100.00
Red wheat meal,	Young Sheep I., .	88.15	25.79	68.49	40.05	93.98	80.65
	Young Sheep III.,	83.41	29.37	65.70	-	90.96	79.29
	Average, . .	85.78	27.58	67.10	-	92.47	79.97
Leaming corn silage.	Old Sheep II., .	67.82	45.58	58.89	68.33	71.38	82.97
	Old Sheep III., .	72.22	54.08	68.93	73.71	74.40	86.31
	Average, . .	70.02	49.83	63.91	71.02	72.89	84.64
White winter wheat meal.	Young Sheep I., .	90.58	10.31	82.68	77.39	94.93	62.24
	Young Sheep III.,	85.97	48.68	80.90	-	92.04	66.46
	Average, . .	88.28	29.50	81.79	-	93.49	64.35
Feed barley meal.	Paige Sheep IV.,	91.36	28.16	90.06	96.01	94.08	85.90
	Paige Sheep V., .	86.58	47.12	86.10	44.78	91.94	86.78
	Average, . .	88.97	37.64	88.08	70.40	93.01	86.34

Discussion of the Results.

Early Amber Sorghum. — This seed was sown broadcast May 25 at the rate of 60 pounds to the acre, and the crop was cut for soiling. It made a satisfactory growth, yielding at the rate of 19 tons to the acre. The digestion trial began August 13, as the sorghum was heading out, and the fæces were collected August 20 to 26, when the plants were fully headed and the seed forming, at which period it is probably at its best for soiling purposes.

Summary of the Coefficients (Per Cent.).

Period I.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep IV., . . .	1	1	69.36	42.98	45.36	71.72	74.04	60.39
Paige Sheep V., . . .	1	1	67.37	40.45	50.91	65.22	73.35	65.10
Average, ...	1	2	68.37	41.72	48.14	68.47	73.70	62.75
Barnyard millet for comparison.	3	6	70.00	56.00	65.00	73.00	71.00	58.00
Corn fodder (immature) for comparison.	5	14	68.00	42.00	66.00	65.00	71.00	68.00

The two trials with the sheep agree quite well with each other, and likewise with millet and corn fodder at a similar stage of growth. The protein only seems to be less digestible than that contained in the other two fodders. Sorghum is eaten well by dairy cattle, is available just before corn is sufficiently mature to be at its best, and is considered a satisfactory addition to the list of soiling crops for Massachusetts. A fuller discussion of the merits of this plant for soiling will be presented later.

Pride of the North Dent Corn Fodder. — The samples were taken from a large field of exceptionally thrifty and well-eared fodder. The stalks were quite stout and the ears fully developed. Sampling was begun September 5, and the fæces were collected September 13 to 19, at which time the grain was in the dough and denting. The entire plant was cut fine before being fed. It contained 77.4 per cent. water and 8.83 per cent. protein in dry matter.

Summary of the Coefficients (Per Cent.).

Period II.

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Old Sheep II., ...	1	1	71.89	40.06	64.45	66.50	77.76	78.37
Old Sheep III., ...	1	1	69.22	28.81	61.03	63.14	76.32	73.75
Average, ...	1	2	70.56	34.43	62.74	64.82	77.04	76.06
Average all experiments, Dent corn fodder for comparison.	9	17	68.00	34.00	53.00	57.00	73.00	74.00

The two sheep consumed the fodder readily, suffered no digestion disturbances and gave closely agreeing results. The average coefficients secured with the two sheep agree as closely as could be expected with the average of all results for mature Dent fodder. The present experiment shows in a very satisfactory manner the degree of digestibility of an excellent variety of Dent fodder that will mature in Massachusetts.

Porto Rico Molasses. — Molasses from Porto Rico has been freely offered in Massachusetts for cattle feeding at a cost of 13 cents a gallon of 12 pounds in barrel lots. The material, while dark colored, was of a satisfactory quality. It contained 20 to 28 per cent. of water (about 24 per cent. average), and in its natural condition about 3 per cent. of crude protein (largely amids), 6.3 per cent. of ash, and the balance cane and invert sugars and allied substances (extract matter). It can be safely assumed that molasses, being quite soluble in water, is easily digested and resorbed in the digestive tract. Three digestion experiments were made by feeding different quantities of the molasses in combination with hay, and hay and gluten feed, in order to note its effect upon the digestion of the other feed stuffs.[1]

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[1] It is a well-known fact that the addition of excessive quantities of starch and sugar causes a distinct depression in digestibility of the other feed stuffs. See summary in Kellner (already cited), page 48.

Summary of the Coefficients (Per Cent.).

Period III.

[800 grams hay, 150 grams molasses and 10 grams salt.]

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep IV., ...	1	1	107.09	92.16	40.43	-	102.76	-
Paige Sheep V., ...	1	1	90.93	80.02	10.17	-	95.80	-
Average, ...	1	2	99.01	86.09	25.30	-	99.28	-

The results show that apparently Sheep IV. digested rather more, and Sheep V. some 9 per cent. less, than the quantity fed. The average coefficients for the two sheep indicate that the dry matter of the molasses was fully digested. It is probably true, however, that in case of Sheep IV. the addition of 150 grams of molasses to the hay ration increased the digestibility of the dry matter of the hay some 7 per cent., and in case of Sheep V. decreased the digestibility of the hay about a like amount. The results can be still further explained by the following figures: —

Sheep IV.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Digested of 800 grams hay fed alone (grams).	408.87	23.43	32.85	133.86	210.30	8.12
Digested of 800 grams hay + 150 grams molasses.	523.71	31.78	34.56	141.89	306.85	8.54
Minus 150 grams molasses fed, assumed to be all digested (grams).	107.24	9.06	4.23	-	93.95	-
Leaves for 800 grams hay digested when fed with molasses.	416.47	22.72	30.33	141.89	212.90	8.54
Difference, ...	+7.60	—.71	—2.52	+8.03	+2.60	+.42

It will be seen that in case of Sheep IV. the feeding of 150 grams of molasses with 800 grams of hay increased the digestibility of the hay 7.6 grams. By this method of feeding the digestibility of the fiber, extract matter and fat in the hay was increased 11.05 grams and the digestibility of the ash and protein depressed 3.23 grams. If 150 grams of molasses increased the digestibility of the hay 7.32 grams (7.60), 100 grams of molasses would increase it 5.1 grams.

Sheep V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Digestion of 800 grams hay fed alone (grams).	408.87	23.43	32.85	133.86	210.30	8.12
Digested of 800 grams hay + 150 grams molasses (grams).	506.38	30.68	33.28	133.82	300.30	8.31
Minus 150 grams molasses fed assumed to be all digested (grams).	107.24	9.06	4.23	-	93.95	-
Leaves for 800 grams hay digested when fed with molasses.	399.14	21.62	29.05	133.82	206.35	8.31
Difference, ...	—9.73	—1.81	—3.80	—.04	—3.95	+.19

Sheep V. digested 9.36 (9.73) grams less hay when the latter was fed with the molasses than when it was fed alone, or 100 grams of molasses caused a depression of 6.05 grams in the digestibility of the hay. The results secured in this particular experiment (Period III.) are contradictory, and definite conclusions cannot be drawn other than to conclude that this quantity of molasses was well assimilated, without causing any serious digestion depression.

Period IV.

[800 grams hay + 250 grams molasses + 10 grams salt.]

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep IV., . . .	1	1	91.89	47.38	-	-	95.35	-
Paige Sheep V., . . .	1	1	88.21	57.54	-	-	95.30	-
Average, ...	1	2	90.05	52.56	-	-	95.33	-

It seems apparent that 90 per cent. of the total dry matter of the molasses was digested, equivalent to one-half of the ash, none of the protein and 95 per cent. of the extract matter. That these results are more apparent than real can be shown from the following: —

Average, Sheep IV. and V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Digested of 800 grams hay fed alone (grams).	404.56	23.19	32.51	132.44	208.07	8.03
Digested of 800 grams hay + 250 grams molasses (grams).	566.92	31.20	32.04	136.99	358.65	8.06
Minus 250 grams molasses fed, assumed to be all digested (grams).	180.30	15.24	7.10	-	157.96	-
Leaves for 800 grams hay digested when fed with molasses.	386.62	15.96	24.94	136.99	200.69	8.06
Difference, ...	–17.94	–7.23	–7.57	+4.55	–7.38	+.03

The average results for the two sheep show that 17.94 (17.60) grams less hay were digested when 250 grams of molasses were fed than when the hay was fed by itself; or 100 grams of molasses caused a depression of 7.2 grams in the digestibility of the dry matter of the hay. The molasses depressed the digestibility of the ash, protein and extract matter of the hay. Excluding the ash, 100 grams of molasses caused a depression of 4.1 grams in the digestibility of the organic matter of the hay. Molasses and hay naturally would not make a satisfactory combination for any kind of farm stock. A more suitable ration would consist of hay, a protein concentrate and molasses; consequently, the digestibility of the latter was tested in combination with hay and gluten feed, with the following results: —

Period VIII.

[600 grams hay, 200 grams gluten feed, 250 grams molasses, 10 grams salt.]

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep IV., ...	1	1	76.50	64.12	-	-	86.93	-
Paige Sheep V., ...	1	1	72.53	65.25	-	-	84.80	-
Average, ...	1	2	74.52	64.59	-	-	85.87	-

It is apparent from the above results that the sheep digested only some 75 per cent. of the total dry matter of the molasses. By assuming that the entire quantity of molasses fed was digested, the following results are secured: —

Average, Sheep IV and V.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Digested of hay and gluten feed when fed *without* molasses (grams).	524.97	18.75	81.88	148.40	264.22	11.74
Digested of hay and gluten feed fed with molasses.	660.31	29.58	79.47	139.96	399.66	11.61
Minus 250 grams molasses fed, assumed to be all digested (grams).	181.68	16.75	7.16	-	157.77	-
Hay and gluten feed digested when fed *with* molasses (grams).	478.63	12.83	72.31	139.96	241.89	11.61
Difference, ...	—46.34	—5.92	—9.57	—8.44	—22.33	—.13

The average results for the two sheep show that 46.34 grams less of the dry matter of the hay and gluten feed were digested with than without the molasses; or 100 grams of molasses caused a depression of 18.5 grams in the digestibility of the hay and gluten ration. Excluding the ash, 100 grams of molasses caused a depression of 3.8 grams protein and 12.3 non-protein substances.

When 250 grams of molasses were fed in connection with hay, the digestion depression for organic matter was at the rate of 4 grams per 100 grams molasses; and when fed in connection with hay and a nitrogenous concentrate, the digestion depression was 16.1 grams. It is intended to repeat the latter experiment by feeding different quantities of molasses with hay and gluten feed, in order to see if the depression continues as high as that observed in the present test.

The average of three complete analyses of Porto Rico molasses has shown it to contain, in round numbers, 24 per cent. of water, 6.25 per cent. ash, 2.75 per cent. protein and 67 per cent. carbohydrates. Inasmuch as the so-called protein is practically all in amido or other forms which are of no value as sources of nutrition, it may be said that the food value of molasses consists in its 67 per cent. of carbohydrates. Applying the digestion coefficient of 86, obtained for the digestibility of the extract matter when the molasses was fed in combination with hay and gluten feed, one obtains 58 per cent. of digestible carbohydrates, equivalent to 1,160 pounds in a ton.

By deducting 16 grams, or 16 pounds (for the digestion depression), from the 70 per cent. of total organic matter, molasses may be said to contain 54 per cent. of digestible organic matter, equivalent to 1,080 pounds in a ton. In the light of the above results, it is evident that 2,000 pounds of Porto Rico molasses contain between 1,080 and 1,160 of easily digestible carbohydrates, and that its crude protein has little or no value as a source of nutrition.[1]

Kellner[2] considers the value of beet sugar molasses to consist in its 55 per cent. of digestible carbohydrates, allowance being made for the digestion depression. Lehmann,[3] as a result of three digestion experiments (9 single trials), feeding hay, cotton-seed or palm-nut meal, and 200, 300 and 400 grams of molasses, secured a digestion depression of 11 per cent., or 11 grams, per 100 grams of molasses fed. Deducting this from the 71 per cent. of organic matter, he declares the value of the beet molasses to consist in its 60 per cent. of digestible carbohydrates.

English Hay. — This hay consisted largely of Kentucky blue grass (*Poa pratensis*), with an admixture of more or less red clover. It was cut when in bloom, well cured, and used in periods V., VI., VII., VIII., IX., XI., XII., XIII., XIV., XV. and XVI.

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[1] One is not likely to feed over 3 pounds of molasses daily to dairy stock or to horses, which is equivalent to approximately 10 per cent. of the dry matter of the total ration. In our digestion experiment with hay and gluten feed, molasses constituted 20 per cent. of the dry matter of the ration; and in Lehmann's experiments, 25 per cent. If only 10 per cent. of the total dry matter in the daily ration should consist of molasses, the question naturally arises as to whether this amount would cause so much of a depression as when larger quantities were fed. This matter is being investigated.

[2] Kellner (already cited), page 350.

[3] Landw. Jahrbücher, Vol. XXV. Erganzungsband 11, 1894, pages 117-120.

Summary of the Coefficients (Per Cent.).

Periods V., VI., IX.

Sheep.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep IV., . . .	1	1	66.05	43.76	60.86	75.44	64.85	49.88
Paige Sheep V., . . .	1	1	64.90	45.44	62.20	72.18	64.06	50.51
Average, ...	1	2	65.48	44.60	61.53	73.81	64.46	50.20
Old Sheep II., ...	1	1	69.38	51.01	63.20	78.04	68.29	55.21
Old Sheep III., ...	1	1	66.36	47.33	61.41	74.55	65.56	49.53
Average, ...	1	2	67.87	49.17	62.31	76.30	66.39	52.37
Young Sheep I., . . .	1	1	66.04	50.60	63.15	72.68	65.01	53.17
Young Sheep II., . . .	1	1	66.75	52.31	60.43	74.87	65.29	55.64
Young Sheep III., . . .	1	1	64.98	52.95	62.37	71.05	63.68	53.88
Average, ...	1	3	65.92	51.95	61.98	72.87	64.66	54.23
Average, seven sheep, . .	1	7	66.35	49.05	61.95	75.55	65.10	52.55
Average all previous trials, similar hay for comparison.	15	60	60.00	47.00	57.00	60.00	61.00	50.00

The three lots of sheep digested the hay quite uniformly. The Old Sheep gave slightly higher digestion coefficients than the other two lots, — a condition which has been noticed in previous trials. The hay proved to have a higher digestibility than the average of previous lots; the high digestibility of the fiber indicates that the lignin substances were only slightly developed, or, in other words, that the grass was tender and comparatively immature.

Gluten Feed. — The sample of gluten feed, consisting of the gluten, skins, starchy matter and broken germs of the Indian corn, was in good condition, although a little below the average in protein.

Summary of Coefficients (Per Cent.).

Period VIII.

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep IV., . . .	1	1	93.78	78.07	89.26	123.46	93.42	75.70
Paige Sheep V., . . .	1	1	97.83	98.67	92.91	128.92	97.03	79.68
Average, ...	1	2	95.81	88.37	91.09	126.19	95.23	77.69
Average previous trials for comparison.	7	13	86.00	–	85.00	76.00	89.00	83.00

The gluten feed appears to have been thoroughly digested, showing higher coefficients than the average of previous trials. It is probable that the addition of the gluten to the hay ration somewhat increased the digestibility of the latter. It not being possible, however, to ascertain to what extent this increase took place, one is compelled to deduct from the total ration the hay digested (using the coefficients obtained for the hay when fed by itself), thus causing most of the gluten coefficients to appear too high [1] (note especially the fiber).

Green Diamond Sugar Feed. — This sugar feed has a similar appearance and is of the same general type as those already reported (see this report, pages 119, 120). Period X. started with two sheep, but the fæces produced by one sheep were so soft that it was not possible to complete the test. Another trial with another sheep was also unsatisfactory. A third trial, in Period XIV., with Paige Sheep IV., was satisfactorily completed.

Summary of Coefficients (Per Cent.).

Periods X. and XIV.

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Old Sheep III., ...	1	1	69.58	38.91	71.52	51.76	78.42	91.65
Paige Sheep IV., . . .	1	1	61.49	36.41	67.61	35.79	70.36	75.49
Average, ...	1	2	65.54	37.66	69.57	43.78	74.39	83.57
Average of three other sugar feeds (Series X.).	3	6	70.44	30.37	61.77	53.30	78.40	88.20
Average all trials, . . .	4	8	69.21	32.20	63.72	50.92	77.40	87.04

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[1] The addition of a concentrated feed rich in protein tends to improve the digestibility of the total ration, especially the fiber. (See Kellner, *loco citato*, pages 51–53.)

Sheep III. digested the feed rather better than Sheep IV. Attention has already been called to the fact that the Old Sheep had a slightly stronger digestion than the others, but why the difference should be so noticeable is difficult to explain.

The protein in the sample of Green Diamond experimented with was better digested than that in the several other sugar feeds. The results secured with Sheep III. and the average results of all trials agree closely; and it may safely be said that this feed has about the same type of composition and a like degree of digestibility as the other sugar feeds examined. The average results of all trials show the sugar feeds to be only moderately digestible, being noticeably less so than either flour middlings or gluten feed.

Sea Island Cotton-seed Meal. — This meal contained a large quantity of hulls, showing only 24–25 per cent. of protein, 5–6 per cent. of fat and some 18 per cent. of fiber. It is claimed that the hulls of this variety of seed are thin, and that it is not possible (or profitable) to thoroughly separate them from the meats.

Summary of Coefficients (Per Cent.).

Period XI.

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Paige Sheep IV., ...	1	1	60.21	80.34	77.14	–	73.02	99.74
Paige Sheep V., ...	1	1	75.69	88.79	80.04	40.32	83.34	100+
Average, ...	1	2	67.95	84.56	78.59	40.32	78.18	100.00
Similar material (Maine), .	1	2	62.00	–	73.00	38.00	68.00	90.00
Cotton-seed meal (high grade),	4	12	79.00	84.00	84.00	35.00	78.00	94.00

Sheep IV. was not able to digest the meal as fully as was Sheep V. The cause of this difference is due largely to the indigestible character of the tough, woody fiber. The coefficients secured at the Maine station for a similar meal are somewhat lower than those obtained in the present experiment.

The fat in the low-grade meal is shown to be nearly all available, while the protein is somewhat less digestible than that contained in a high-grade meal; the chief difference, however, in the digestibility of the two grades is to be found in the total dry and extract matter, decidedly lower coefficients being secured from the low-grade meal containing a high fiber percentage. Cotton-seed meal of first quality should contain in 2,000 pounds about 700 to 760 pounds protein, 44 pounds fiber, 380 pounds extract matter and 192 pounds fat, or 1,346 pounds digestible organic matter in one ton. A low-grade meal will contain 380 pounds protein, 144 pounds fiber, 540 pounds extract matter and 142 pounds fat, or 1,206 pounds digestible organic matter in a ton. The low-grade meal contains only about one-half as much of the most valuable ingredient (digestible protein) as does the high-grade meal. The former meal will likewise require considerably more energy for its digestion.

Leaming Corn Silage. — The Leaming corn is a large dent, that will usually mature its grain in Massachusetts. The silage was in nice condition, and was made from matured and well-eared corn. The sheep ate the silage well, continued in good condition, and during the entire trial left only 25 and 40 grams each of the hard butts.

Period XIII.

[400 grams hay, 1,600 grams silage, 10 grams salt.]

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Old Sheep II., ...	1	1	67.82	45.58	58.89	68.33	71.38	82.97
Old Sheep III., ...	1	1	72.22	54.08	68.93	73.71	74.40	86.31
Average, ...	1	2	70.02	49.83	63.91	71.02	72.89	84.64
Dent silage, mature, all trials for comparison.	9	25	66.00	37.00	50.00	64.00	71.00	82.00

The two sheep showed closely agreeing results except in case of the protein, Sheep III. digesting 10 per cent. more than Sheep II. The Leaming corn is highly esteemed by many farmers for silage purposes; and the fact that it will generally mature its grain, together with its high degree of digestibility, as shown by the above coefficients, shows the preference to be a wise one. The average results of the two trials are rather higher than the general average of all experiments with different varieties of Dent corn.

Red and White Wheat and Barley Meals. — The several grains were purchased of local dealers. Neither variety of wheat was suitable for milling; the former contained some shrunken berries and a few weed seeds, and the latter, while fairly plump, was off color. The barley was known as "feed barley;" it was not plump and full, and was a trifle musty. The grains were sold as food for poultry, and may be considered of a fairly satisfactory quality for such a purpose. The red wheat retailed at $1.65, the white at $1.80 and the barley at $1.30 per hundred pounds. The analyses and the digestion trials were made for the purpose of ascertaining their relative values for feeding purposes.

Composition (Per Cent.).

FEED.	Water.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Red wheat,	12	1.69	8.76	2.64	72.45	2.46
White wheat,	12	1.67	11.50	2.11	70.84	1.90
Feed barley,	11	2.91	12.99	5.52	65.78	1.80

Each of the two samples of wheat contained a trifle less than 12 per cent. water, and the results were therefore calculated to that basis for comparison. The white wheat tested a little better than the red, containing nearly 3 per cent. more protein and a little less fiber. It is doubtful, however, if these figures would hold true in all cases. In fact, it is well known that both climate and soil have great influence on the quality of wheat and gradually modify varieties.

The barley showed rather more protein than is usually found in this grain. It is probable that it had not been fully ripened when cut, thus preventing the most complete development of the starch.

Summary of Coefficients (Per Cent.).

Periods XII., XV. and XVI.

[Red Wheat.]

SHEEP.	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Young Sheep I.,	1	1	88.15	25.79	68.49	40.05	93.98	80.65
Young Sheep III.,	1	1	83.41	29.37	65.70	–	90.96	79.29
Average,	1	2	85.78	27.58	67.10	–	92.47	79.97
[White Wheat.]								
Young Sheep I.,	1	1	90.58	10.31	82.68	77.39	94.93	62.24
Young Sheep III.,	1	1	85.97	48.68	80.90	–	92.04	64.35
Average,	1	2	88.28	29.50	81.79	–	93.49	63.30
Average, both varieties,	2	4	87.03	28.54	74.44	–	93.00	71.30
[Feed Barley.]								
Paige Sheep IV.,	1	1	91.36	28.16	90.06	96.01	94.08	85.90
Paige Sheep V.,	1	1	86.58	47.12	86.10	44.78	91.94	86.78
Average,	1	2	88.97	37.64	88.08	76.40	93.01	86.34
Corn for comparison,	9	21	88.00	–	66.00	–	92.00	91.00

The grains were ground in each case before being fed. Both varieties of wheat were well digested; the white wheat appeared to have been slightly better digested than the red. The barley was likewise quite fully digested, showing 89 per cent. of digestible dry matter and 88 per cent. of digestible protein. The ratio of digestible protein to carbohydrates in the red wheat was 1 to 9; in the white wheat, 1 to 7.4; and in the barley, 1 to 6.8. The increased digestibility of the protein in the white wheat and feed barley over that contained in the red wheat is due probably to the relatively higher percentage of protein in the latter two grains, and consequently in the two total rations.[1] It is believed that the protein in ordinary grains (maize, wheat and barley) is equally and quite fully digested, providing it is fed in a ration having a ratio of 1 to 8 or less; and that the apparent low coefficient (see present red wheat protein coefficient, and average protein coefficients for maize) is due largely to the above-mentioned cause.[1] A further study of the coefficients of wheat, barley and corn, as given on the previous pages, shows the extract matter to have practically the same degree of digestibility.[2]

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[1] For every 100 grams of dry matter fed, a reasonably definite amount of nitrogenous metabolic by-products are egested, mixed with the fæces, whether the ration is rich or poor in protein. It follows, therefore, that the smaller the amount of protein in the total ration the smaller will be the amount of protein left (digested) after these by-products which are included in the fæces have been deducted.

On the basis of composition and of the digestion coefficients secured, the white variety of wheat is shown to be some 9 per cent. more valuable than the red. Whether this would hold true as a general rule is not known. Other things being equal, the higher the protein content of the wheat the more valuable it is.

Taking the value of all the ingredients into consideration (protein, fiber, extract matter and fat), an average quality of "feed barley" appears to be about as valuable as an average quality of white wheat, and both grains figure slightly more valuable than maize (8 per cent.). Kellner [3] considers these three grains to have very nearly equal relative values, and as sources of carbohydrates this estimate must be correct. Brooks [4] has called attention to the fact that, with a plentiful supply of animal protein, corn gives rather better results than wheat for egg production, and at less relative cost. In view of their composition and digestibility, it would seem as if there were no reason to expect any particular difference in the feeding effect of these two grains. It is possible, however, that the energy required for the digestion of the wheat might be greater than that required to digest the corn. It is well known that poultry are particularly fond of corn and moderately so of wheat, but do not care especially for barley. This fact should not be overlooked in comparing the relative merits of corn, wheat and barley for this class of stock.

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[1] For every 100 grams of dry matter fed, a reasonably definite amount of nitrogenous metabolic by-products are egested, mixed with the fæces, whether the ration is rich or poor in protein. It follows, therefore, that the smaller the amount of protein in the total ration the smaller will be the amount of protein left (digested) after these by-products which are included in the fæces have been deducted.

[2] The digestion experiments thus far made with poultry show the dry matter in corn to be 87, protein 84 and extract matter 92 per cent. digestible; and in wheat dry matter 84, protein 77 and extract matter 89 per cent. digestible. In other words, poultry digest the two grains to about the same extent as sheep.

[3] *Loco citato*, page 561.

[4] Eighteenth report of this station, page 152.

REPORT OF THE BOTANIST.

G. E. STONE; ASSISTANT, N. F. MONAHAN.

OUTLINE OF WORK.

The work of this department has been devoted during the past year to lines of investigation pertaining to scientific and practical problems. Attention has been given to the spraying of potatoes, and to a study of the stimulating or tonic influence of the Bordeaux mixture on the photosynthesis of plants. It has long been recognized by many observers that Bordeaux mixture, besides possessing valuable fungicidal properties, exerts a tonic effect on plant assimilation. The factors underlying the cause of this favorable influence upon assimilation, however, are not well understood, and investigations are to be continued relating to this problem.

A continuation of our studies of a remedy for tomato rot under glass has been carried on, and it will be necessary to continue these investigations still further before a report is made. It is hoped that the necessary funds for a new greenhouse will be appropriated this winter by the Legislature, in order that this work and other problems associated with greenhouse culture may be investigated. There is a large amount of money invested in greenhouses at the present time in Massachusetts, and we believe we are within the limits of safety when we state that the square feet of greenhouse space in Massachusetts has been doubled within the past five years. Little attention has been given to this line of investigation by other stations, and the market-garden and florist industry is important enough, in this State at least, to receive considerable attention.

During the past summer tests have been made of some blight-resisting cantaloupes which were originated in Colorado. It is hoped that further observations may be made on cantaloupes, with the idea of securing blight-resisting types, since at the present time crops of melons free from blight are a rarity in Massachusetts.

Some bacterial investigations have been carried on which possess a bearing on various problems, but it is not deemed advisable to report on this work at the present time.

This also holds true in regard to some minor experiments with electricity as related to plants. Extensive observations have been made in regard to the bearing of light upon plant growth, more particularly in regard to greenhouse construction and other problems.

During the coming year we expect to take up the study of some climatic influences which affect the production of both greenhouse and out-door crops. The production of crops is so intimately associated with such factors as light, heat, moisture, etc., — factors which are scarcely appreciated except by skilled greenhouse growers, — that a more extensive study of them would prove of value.

During the year a large number of mechanical analyses of soils have been made by this department, most of which were rose soils. These analyses were made for expert rose growers, who desired to secure suitable soils for the growth of American Beauty and other roses.

Seed Work.

There is a constantly increasing demand upon this department for work pertaining to seed germination, seed separation and purity testing of seeds. The department is not at present sufficiently well equipped for purity testing, since the best work in this line can be done only by a specialist, or by one who is able to devote considerable study to the subject.

Most of our seed separation is done for tobacco and onion growers of the Connecticut valley, and for this work the department has installed efficient appliances. It is hoped that market gardeners will eventually separate their seed, since in growing such crops as lettuce, celery, radishes, etc., this practice would prove valuable.

The following table gives a condensed statement of the work done by this department on seeds during the year: —

Records of Seed Work for 1906.

	Number of Samples.	Number of Seed.	Weight (Pounds).	Good Seed (Per Cent.).	Discarded Seed (Per Cent.).
Germination tests, . . .	126	19,567	-	58.8	-
Purity test, ...	18	-	-	-	-
Seed separation: —					
Onion, ...	13	-	129.6	83.8	16.2
Tobacco, ...	74	-	24.1	80.3	19.7
Total, ...	231	-	-	-	-

The average percentage of germination of onion seed was 79.5; of sweet corn, 71.9; and the highest percentage of onion seed germination was 100, while the same percentage was obtained with samples of sweet corn. The lowest percentage of germination of onion was 28; that of sweet corn, 25. In practically all cases 200 seeds were employed in each test, and smaller numbers were used only when the number of seeds sent in was less. Occasionally more than one test was made, and the average in such cases was taken. The onion seeds tested during 1906 were particularly good, being much better than those we have tested during previous years. Both onion and tobacco seed were separated by air. Only 2 per cent. of seed was discarded by the process of air separation from the best tobacco seed sent in, while from the poorest samples 37 per cent. was discarded. In the case of the best onion seed, 8 per cent. was discarded by the use of a winnowing machine, while only 20 per cent. was discarded from the poorest samples of onion seeds.

PREVALENCE OF FUNGI, ETC.

One of the peculiarities of the different seasons is that no two are alike as regards the prevalence of certain pathogenic fungi. The potato has been comparatively free from disease during the past season; but there was more or less trouble with celery, particularly in the summer, when there was a period of rather dry weather; and later in the fall there was much complaint of celery blight. Pear and apple blight were unusually prevalent this year, more so than they have been for some time. An unusually large number of samples of pear and apple blight were sent in to the station for diagnosis during the spring and early summer. More or less defoliation of apple trees has occurred, resulting in part from the late spring frosts, which caused blisters on the leaves; and from the use of spraying mixtures.

A considerable amount of trouble is being experienced in the defoliation of apple trees at the present time in various parts of the United States, which is presumably caused by spraying. Some of this trouble is to be found in our State, and we surmise that it may be due in some cases to the use of inferior Paris green in Bordeaux mixture, and in other cases to the Bordeaux itself. The Baldwin apple spot has been more or less prevalent during the past season, and some trouble has been experienced from apple scab.

A widely distributed and common trouble has occurred on apple trees during the past season, which is termed sun scald. This was more noticeable on small branches, particularly on those which were shaded. This same diseased condition was noticeable on other fruit trees, such as the peach and plum; and on some wild shrubs, like the cornels. The effect of sun scald was in some instances of an insignificant nature; while in others it resulted in a partial girdling of some of the branches, which was followed by a poor development of the foliage, and in some cases many of the twigs died.

Sun scald is the result of a non-ripening of the wood; and it is significant that most of the branches affected with this trouble are those hidden from the sun, which prevents the wood from ripening as thoroughly as those which are exposed to the sun.

For the last two or three years sooty mold on the pear has given rise to considerable trouble. This is caused by fungi which grow in the honey-dew secreted by psylla on the leaves and branches. As a consequence of this fungous growth, there results a clogging of the pores of the leaves, which renders them unhealthy, causing them to fall prematurely. The young twigs and branches become covered with a thick black growth, resembling soot, which interferes with their normal functions, thus checking their growth. A satisfactory way of ridding the branches of this sooty growth is not known to us at the present time, and from reports which we have received it would appear that the lime and sulfur treatment has no effect upon it. The best method of prevention is to kill the psylla, which can be effectively done by spraying.

Some incidental observations have been made during the year on diseases which are unusual, at least in this region; and these will be referred to briefly, since it is necessary that further studies of these be made before it can be ascertained whether they are likely to cause much trouble. Our attention has been called a few times to some greenhouse tomato troubles, one of which is probably the Fusarium wilt, or "sleeping disease," as it is termed, — a trouble which has been reported elsewhere.

Another tomato trouble which has been brought to our attention is probably identical with Œdema, and is caused by abnormal heat and moisture conditions. In another case a bacterial trouble of the tomato was observed which was undoubtedly brought about by the exceedingly poor management of the crop.

Two new or little-known asparagus troubles were noticed during the past season, one of which is undoubtedly a Rhizoctonia rot, which is mentioned as occurring on asparagus by Saccardo. We were not able to make an elaborate study of this asparagus infection, owing to the limited amount of material which was at hand. Most Rhizoctonia troubles are serious, and it remains to be seen whether this will prove to be so or not.

Bacterial Disease of Cucumbers.

The bacterial disease of cucumbers, termed by Dr. Erwin R. Smith "bacteriosis," has been seen here in summer for some years on out-door cucumber crops. My attention, however, has not been called to its appearance on greenhouse crops until this year; but if the reports and descriptions of this disease are correct, it has occurred in more than one greenhouse during the year.

In only one case have we had opportunity to examine an affected crop, and this was totally destroyed during October. This crop was started in August, and, like most crops of cucumbers started in midsummer, it was affected with downy mildew (*Plasmopara Cubensis,* B. & C., Humphrey). The soil in the house was of good texture for cucumbers, and well provided with horse manure and commercial fertilizers, as was evident from the vigorous growth of the plants. About the time the plants had reached a height of seven or eight feet and had set a large amount of fruit the leaves commenced to wilt, and in a few days most of the foliage collapsed, leaving only a few unaffected leaves at the top of the plant, which necessitated the removal of the entire crop. Adjacent to this greenhouse were other larger houses, which, however, were planted somewhat later, and the plants in these houses entirely escaped infection.

Bacteriosis of cucumbers has been rare, if it has occurred at all, under glass in this State. A few years ago we secured germs from an affected out-door crop of cucumbers, and inoculated the soil in our greenhouse in which cucumbers were growing, with the result that not the slightest infection occurred in any instance. The experiment was made during the fall and winter months, which may account in part for the failure of the germs to infect the plants.

There is always risk in planting a cucumber house in August, since the downy mildew previously mentioned, and Anthracnose (*Colletotrichum Lagenarium* (Pass.) Ell. & Hals.), are sure to be present during August in full force; and the same probably is true to a certain extent in regard to the germs of bacteriosis. At any rate, it is a significant fact that nearly every house planted late has none of these troubles to contend with.

In the case of the bacteriosis described above we are of the opinion that the method of growing the crop had something to do with its susceptibility to infection, since the plants were in our estimation somewhat too vigorous growers, and did not possess the best texture.

We have frequently advised growers of cucumbers not to plant in August, on account of mildews, etc. There is much less risk in planting in September, and scarcely any during any time in October. If a house of cucumbers is planted in August, it is necessary to ventilate freely, apply little or no water to the foliage, and keep down the moisture in the atmosphere to the lowest degree, in order to hold mildews and Anthracnose in check.

Bacterial Disease of Lettuce.

Our attention has been called at different times to an undescribed bacterial disease of lettuce, which is reported as causing considerable damage in some localities. This disease has been observed in our greenhouse for many years, and during the year 1901 Mr. Percival C. Brooks, then a member of the senior class in botany, investigated this problem. He succeeded in isolating an organism from a diseased lettuce plant, and obtained positive results from his inoculation experiments with healthy plants.

The disease in question has never been observed by us in this State except in our own house, notwithstanding the fact that we have for many years had occasion to carefully study the various lettuce crops in the State, and have constantly been on the lookout for it. Neither has careful inquiry brought to light any trace of a similar affection in lettuce houses in Massachusetts. Since the disease occurred in our lettuce house on crops which had been forced too rapidly, it was considered of little consequence and was given scarcely any attention, inasmuch as we thought the trouble arose from improper management of the crop. Our only purpose in calling attention to this disease at the present time is that it is reported as doing considerable damage elsewhere, particularly in the south, which makes it desirable that we should be on the lookout for it. The disease results in the appearance of numerous small brownish spots about the size of a pin-head on the young and tender light-colored leaves of the head. The spots are frequently quite numerous, and in some cases run together, causing a destruction of a portion of the leaves of the head. No attempt was made by Mr. Brooks to make any extensive study of the organisms causing the disease, since at that time it was believed to be of little consequence, and only an accompaniment of too rapid forcing. In some localities, particularly farther south, we hear different reports concerning its prevalence.

Bacteriosis of Geraniums.

In a previous publication of this station a short note was made of a bacterial disease of geraniums occurring in this State.[1] Since that time we have made yearly observations on the prevalence of this disease in various sections. It has appeared every year since it was first noted here in 1898, and has also been reported from various other sections of the United States within recent years.

Our observations have shown that it has frequently been abundant and generally distributed, so much so at times that gardeners have been more or less concerned about it. We have also noticed this disease in greenhouses each year, it having apparently been brought in with out-door stock, although it does not appear to be serious under glass. Our observations have shown that the trouble is more frequently found on plants exposed to bright sunshine than on those growing in shade, and is evidently more severe farther south, where the light is more intense than in Massachusetts. Geraniums require comparatively little light for their best development, and a strong light may favor the development of this disease.

The disease affects the leaves, causing spots to appear on them. The spots are often numerous and sometimes coalesce, which causes the diseased portions to dry up and turn brown. The spots are about one-eighth of an inch in diameter, and resemble blisters. No other portion of the plant is affected. Examination of a large number of diseased sections shows only a few bacteria present in the tissues except in those cells bordering on the outer portions of the spots.

The geranium is a very hardy plant, and one of the freest from disease. No attempt has been made to treat this disease, to our knowledge, and should it become more troublesome some remedy for it will have to be discovered.

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[1] Tenth annual report, Hatch Experiment Station, 1898, page 67.

Tobacco Troubles.

Some troubles, due to methods of handling the crop, occasionally occur on tobacco growing in the Connecticut valley. Instances have been known for years where the crops have been set back by the use of certain fertilizers and methods of applying them. Tobacco, corn and other crops, moreover, show a tendency to stand still or make little growth on soil in which there is an overabundance of moisture.

Our attention has been called to a tobacco trouble which appears to be caused by the use of fertilizer. In one particular field which we examined the roots of the plants had all the characteristic symptoms of fertilizer burning, and careful examination failed to reveal any fungi associated with this trouble. The tap roots of all the plants which we examined had been destroyed, and new secondary roots had developed freely on the injured end of the tap root. These were endeavoring to penetrate to the lower strata of the soil, and would in turn become burned on the tip before reaching any great distance.

The effect on the crop manifested itself in a stunted growth, the plants remaining in this condition for weeks. When plants affected with this trouble were removed to other soils they would in all cases make rapid growth. Even in the field where the trouble occurred they would reach a fair degree of maturity at the time of harvesting. There appears to be absolutely no connection between this trouble and the seed bed, since other fields close by were planted from this seed bed, and not the slightest evidence of the trouble was to be seen. Moreover, it occurs on new tobacco land as well as on old. It was as severe on land which had been planted this year for the first time as it was on old land.

The trouble apparently seems to have no inclination to spread, since a field only ten or twelve feet away from the infected one, planted with seedlings from the same seed bed, showed no trace of it. It is much more conspicuous in low places which receive drainage from the surrounding soil than on the drier knolls.

At present, at any rate, the trouble must be attributed to mistakes in fertilizing, since no fungi are associated with it; and the only difference between the cultivation of this particular crop in which the trouble occurred and other surrounding ones, some of which had been planted from the same seed beds, consisted in the methods of fertilizing.

Monilia on Peach Stem.

For a number of years we have received peach twigs in this department which have been conspicuously spotted. The spots appear on one-year-old wood, and are of an ash or greyish color in the center, with a more highly colored, generally purple margin. Examination of these spots has invariably revealed the presence of a species of Monilia which extends scarcely below the epidermis. Occasionally the spores of Cladosporium are to be found, but by no means frequently. Some years the spotting appears to be much more common than others, and there is generally little difficulty in finding it in orchards during such periods. Cultures from the spots have always produced Monilia. Mr. F. A. Bartlett, now of Hampton Institute, Hampton, Va., and formerly a senior in our laboratory, during the year 1905 made many isolations and cultures of this fungus. He was not able to complete his studies of the fungus, but from his observations it would appear that a species of Monilia was the sole cause of this spotting. Mr. Bartlett thus verified observations which had been previously made by my former assistant, Prof. R. E. Smith, and myself. From Mr. Bartlett's various cultures it would appear that the spores of Monilia causing this spotting to peach twigs are not the same as those occurring on the fruit (*Oidium fructigenum*)[1] but is a different species, possessing smaller spores, and otherwise differing from the species attacking the fruit of the peach, etc.

There are various Monilia and Cladosporium troubles which affect the peach described in experiment station publications and foreign pathological journals, all of which appear to differ from this one in its effect upon twigs.

We hope to make further investigations of this trouble, and in the meanwhile it may be mentioned that where the lime and sulfur treatment has been applied to peach trees for the San José scale not the slightest trace of this spotting can be found, showing that this mixture has a very repressive influence upon the fungus.

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[1] *Oidium fructigenum*, Kze. & Schm.

THE LIME AND SULFUR MIXTURE AS A FUNGICIDE.

The increased activity of the San José scale during the past two years has resulted in more attention being paid to the spraying of orchards. This has been the means of reducing very perceptibly many of the troubles to which orchards are subject. Our examinations of a number of orchards during the past summer which had been sprayed with the lime and sulfur mixture have convinced us that this mixture is one of the most reliable fungicides known for the suppression of certain fungous diseases. It is especially applicable for the control of such diseases as the peach leaf curl, as has been previously pointed out by many observers. It is equally valuable in the treatment of Monilia and Cladosporium, which occasionally attack the stem.

The large and exceedingly well-cared-for orchard of Mr. Elbert Bliss of Wilbraham offers one of the best examples of the efficiency of the San José mixture as a fungicide. His orchard, which covers many acres, was absolutely free from any blemish due to fungi, both as regards foliage and wood. The college orchard, which was sprayed for the San José scale with the lime and sulfur mixture, has been remarkably free from fungous troubles during the past season. Our observations of other orchards have seemed to indicate that spraying with the lime and sulfur mixture succeeds in controlling to some extent canker, pear blight, black knot and other diseases. We have frequently advocated early spring spraying of trees before the leaves appear, with a solution of copper sulfate at the rate of 1 pound to 50 gallons of water, as we maintain that many of the common blights are more successfully prevented by this spraying than by later ones. It has been shown that early spraying with copper sulfate has been successful in holding in check the black knot of the plum.

The San José scale may prove in more than one way a "blessing in disguise."

Potato Spraying Experiments.

A large field of potatoes on the college farm was used for experiments in spraying the past season. The field was located on the west slope near the farm barn, and included seven acres. The following varieties were planted: Early Harvest, Early Michigan, Carmen Number Three, Green Mountain and Delaware. These were planted in rows running lengthwise of the field. The experiment was carefully planned as regards varieties, conditions of the soil, etc., and running parallel to each of the various treated rows were left untreated ones for the purpose of comparison.

As there was some delay in obtaining the spraying mixtures, the whole field, including the checked plants, was sprayed once with Paris green for the potato beetle. In subsequent sprayings the following mixtures were used: wet Bordeaux containing Paris green, dry Bordeaux, copper phosphate and a mixture termed "1—2—3." The wet Bordeaux was made according to the standard formula (4—4—50). The other mixtures were proprietary substances, and were furnished by the Bowker Insecticide Company, which to our personal knowledge has always taken great pains to place on the market only the most reliable fungicides and insecticides. The "1—2—3" contained compounds of copper, arsenic and lime. The dates of the three applications were July 3, 7, and 12, no spraying being done after the latter date, on account of the luxuriant growth of the tops, which prevented access to the field without damage to the crop. The copper phosphate, dry Bordeaux and "1—2—3" are all dust sprays, and were applied early in the morning with a dust sprayer, when dew covered the foliage. The effects of spraying on this crop were carefully observed by various members of the station staff, together with Mr. Forristall, who supervised all the work, and made most careful observations as to the effects of the different sprays.

At the close of the experiments corresponding rows of the treated and untreated plants were dug, the potatoes carefully weighed by Mr. Forristall, and the results tabulated. The yields given by the various treatments are as follows: —

Average Yield of Sprayed Potatoes.

TREATMENT.	Average Yield (Pounds).
Wet Bordeaux,	55.98
Dry Bordeaux,	58.11
Copper phosphate,	52.34
"1—2—3,"	55.88
Untreated,	55.46

These results show no differences in the yield which can be ascribed to spraying. Observations on the condition of the crop during the summer did not show any material differences except in the case of the wet Bordeaux treatment, which was perceptibly superior in all respects to the others, at least during the greater part of the season. The plants treated with wet Bordeaux possessed the darkest-colored foliage, and were by far the most free from the flea beetle. The season was remarkably free from potato blights, the only thing occurring of any consequence being the flea beetle; and, with the exception of the wet Bordeaux, which contained Paris green, there appeared to be little or no difference between the treated rows and those untreated. At the time the potatoes were dug there was no perceptible difference to be observed between any of the rows. Owing to the season's comparative freedom from blight, little or no value can be placed upon these experiments.

The ease with which dust sprays can be applied makes the process of spraying less tedious, and a dust spray which possesses the merits of other reliable sprays on the market would be gladly received. However, careful tests of the relative merits of the wet and dry sprays indicate that the wet Bordeaux is superior in all cases to the dry.

Our potato growers should realize that the conditions in this State are entirely different from those in Vermont and Maine, and the spraying calendar recommended for those States is unsuited to our conditions, since their spraying is largely devoted to the control of the late blight, which is not generally severe here. On the other hand, it is the early blight, according to our experience, which does the most damage in Massachusetts; and in order to prevent attacks from this, farmers should commence to spray when the potatoes are not more than one-fourth grown, which would ordinarily be about the 20th of June. Much of the injury to potatoes is due to the flea beetle, which affects them in a manner similar to the early blight.

We believe that a first spraying of potatoes should be made with Bordeaux and "Disparene," instead of Paris green, since "Disparene" is a reliable insecticide, while Paris green is not, at the present time.

Copper Sulfate Treatment of Stagnant Water.

In a previous report we gave the results of a copper sulfate treatment of the college pond.[1] This pond is located on the college grounds, and contains about 8,000,000 gallons of water; it is quite shallow and has a muddy bottom. The amount of water which it receives during the summer months is not sufficient to cause a very constant overflow, and partly for this reason it occasionally becomes stagnant. There is also some pollution from cesspools which drain into it, and during freshets considerable amounts of fine sand, silt and clay are carried into the pond. Much of this silt, etc., remains in suspension for a long time, giving the water a yellowish tinge and roily appearance. Evaporation tests show that the water contains 45.6 parts sediment to 10,000 parts of water. During June the water usually has a disagreeable odor and becomes quite obnoxious. This odor is similar to that which rises from frog ponds where considerable decomposition takes place, and at other times it has the odor which is characterized as "fishy."

The pond has frequently been drained, which is responsible for stimulating growths of algæ, particularly Spirogyra, and for the past few years Anabæna has been present in greater or less amounts. It should be stated at the outset that our object in treating the pond was not to clear up points of controversy in connection with the copper sulfate method of treatment; it was done largely to obviate a nuisance.

That copper sulfate has an effect upon algæ has been known to physiologists for many years; but the treatment of large volumes of water with this chemical is, so far as we know, comparatively recent. Those who wish to become familiar with the more technical features of this subject are referred to the older literature, much of which is in German, and to the more recent publications of the United States Department of Agriculture and our own State Board of Health.

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[1] Eighteenth annual report, Hatch Experiment Station, 1906, pages 143–146.

The treatment given during 1906 was similar to that of 1905, and consisted in applying 1 part of copper sulfate to 4,000,000 of water. The copper sulfate was placed in a coarse bag attached to a canoe, which followed concentric circles over the pond until the copper sulfate was all dissolved. Samples of water were taken daily for bacterial examination a few days before treatment and each day after until July 19, when the experiment was discontinued. The usual bacterial methods were employed, with the following results: —

Table showing the Results of treating the College Pond with Copper Sulfate at the Rate of 1 Part of Copper Sulfate to 4,000,000 of Water. (Treated June 14, 1906.)

[Number of bacteria per c. c. of water.]

June 10,	7,005[1]	June 26,	846
11,	6,034[1]	27,	1,085
12,	5,757[1]	28,	1,231
13,	7,188[1]	29,	1,265
14,	7,158[1]	30,	1,006
14,	130[2]	July 1,	1,365
14,	56[3]	2,	1,231
15,	142[4]	3,	1,308
16,	156	4,	1,231
17,	156	5,	1,006
18,	341	7,	1,084
19,	554	9,	1,000
20,	769	11,	1,208
21,	1,000	13,	1,208
22,	1,000	15,	1,275
23,	756	17,	1,462
24,	768	19,	1,770
25,	927		

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[1] Before treatment.

[2] One hour after treatment.

[3] Two hours after treatment.

[4] Twenty-four hours after treatment.

The number of bacteria per cubic centimeter showed a decided falling off after the treatment, but subsequently an increase was noticed, although the number did not equal that present before treatment. The first bacterial examination of the water occurred one and two hours respectively after treatment, at which time there was noted considerable decrease in the number of organisms. It seems hardly creditable, however, that the copper could have been sufficiently diffused in the pond to cause such a rapid decrease in the number of the bacteria in so short a time. Some Anabæna were present in the pond previous to treatment, but none was observed directly afterwards; neither were any Spirogyra noted either before or after treatment. On the other hand, there were various forms of life, such as Daphnia, etc., present, both before and after treatment. No chemical analyses of the water were attempted, since the ordinary methods of analysis are not especially valuable in detecting slight traces of copper in water. It would appear from the culture of seedlings in glass vessels containing water and sand in which copper is present, and from the results of chemical analyses of the mud in the bottom of the reservoir, that a large amount of copper is taken up by this mud. The results of copper treatment of the pond in 1905 and 1906 show that the bacteria never regained their former numbers.

In a pond like this one, which is more or less polluted from cesspools, one would naturally infer that bacteria would increase rapidly after a few days. During August the pond was in an even worse condition than in June, as a large number of dead fish, termed " suckers," which had died from some unknown cause, were floating on the surface. Again during October there was a fairly luxuriant growth of Anabæna present for a few days, but this disappeared quickly, presumably on account of the rather cold nights which occurred at that time.

At the time the treatment was under way, parallel laboratory tests were made. For this purpose we employed 18 liters of water from the college pond in two rectangular jars, there being 9 liters in each jar, one of which was treated with copper sulfate at the rate of 1 part of the sulfate to 4,000,000 of water, while the other jar was left untreated. The jars were placed side by side in the laboratory, and exposed to the organisms of the air. The water was taken from the pond previous to its being treated. The results of the experiments are shown in the following table: —

Table showing the Results of treating Pond Water with Copper Sulfate at the Rate of 1 Part of Copper Sulfate to 4,000,000 of Water. (Experiment made in Laboratory, in Glass Aquaria Jars.)

[Number of bacteria per c. c. of water.]

DATE.	Pond Water untreated.	Pond Water treated.
June 14,	7,158	30[1]
15,	5,723	15
16,	4,849	38
17,	4,849	32
18,	4,444	24
19,	6,188	31
20,	7,927	43
21,	6,112	59
22,	4,772	101
23,	6,362	120
24,	5,313	54
25,	6,273	134
26,	7,004	126
27,	6,927	98
28,	8,282	170
29,	8,926	242
30,	6,419	310
July 1,	7,004	270
2,	7,409	298
3,	8,107	340
4,	6,792	930
5,	7,972	872
7,	10,168	800
9,	6,412	1,060
11,	6,989	1,000
13,	7,399	940
15,	6,034	946
17,	8,632	1,390
19,	10,656	1,240

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[1] One hour after treatment.

The results shown in this experiment coincide in a general way with those of the previous one. They are, however, of more value, since they show the bacterial flora of the normal or untreated pond water.

It will be noted that the number of bacteria in the untreated pond water remained quite constant throughout the experiment, while the water treated with copper sulfate showed the same general decrease in the number of bacteria. The subsequent increase in the number of bacteria in the treated water in the laboratory experiment was smaller than that shown by the pond experiment. Furthermore, a comparison of the two jars in the laboratory experiments showed that the water in the treated jar was much clearer, owing to the fact that most of the forms of living matter had been killed and had settled to the bottom of the jar. This was proved by the much larger amount of sediment in the bottom of the treated jar than in the untreated.

Large bodies of water can be successfully treated with copper sulfate, and many undesirable forms of organisms eliminated. The copper sulfate treatment, moreover, appears to exert an influence upon the bacterial flora for quite a length of time; but after a certain period has elapsed a body of water may become as badly contaminated with various forms of living matter as before, or even worse.

The location of the college pond is such that no harm could result in any way from a treatment with copper sulfate, even though some of the copper escaped. Precautions, however, must be exercised in treating bodies of water; and the safest method to follow, in case such treatment is necessary, would be to consult our State Board of Health or others familiar with this subject.

Banding Substances for Trees.

In connection with the renewed warfare against the gypsy and brown-tail moths, a number of new banding substances, which are claimed to be effectual as insect barriers and harmless to trees, have been placed on the market within a year or so. These substances are sold under various names and at varying prices, and they are quite dissimilar in their chemical composition and in the effects produced on trees. Any substance which is likely to cause even the slightest injury when applied to trees should not be employed, and when such substances actually cause the death of trees, it becomes a gross offence to apply them to public shade trees.

At the request of William B. de las Casas, Esq., chairman of the Metropolitan Park Commission, the writer made an examination during the summer of 1905 of a large number of trees located in Middlesex Fells and other districts around Boston, with a view to determining the effects of the various so-called banding substances on trees.

In addition to our numerous examinations of the effects of these various substances on trees, we have tested a great many in a critical way on small plants. Our conclusions relating to the effects of the substances are based upon a larger number of observations, together with numerous tests on stems, leaves, etc., of a variety of herbaceous plants. Any substance which causes injury to herbaceous plants may also produce the same effect on trees, although the time necessary to produce injury to herbaceous plants is brief compared to that necessary to give rise to corresponding results in a tree.

A good banding substance should not cause the slightest injury to trees, or even to tender tissues. It should not harden at low temperature, neither should it melt at comparatively high temperature. It should be inconspicuous when applied to the tree, and easily put on and removed, and should remain sticky during the entire season.

Tanglefoot. — This material is now extensively used, and is a semi-transparent, sticky substance, not affected by low temperature (32° F.) or by temperatures under 125° or 130° F. Its principal bases are probably castor oil, resin and wax, which are substances harmless to vegetable tissue; and, whatever the other constituents of this banding substance may be, they do not render it harmful to trees. Tanglefoot applied to a large number of plants possessing a thin epidermis has never caused any injury. In short, this is the only substance which we have met which stands all the tests a perfectly harmless banding material should when applied directly to plant tissue.

Bodlime. — This is the proprietary name of a substance resembling Raupenleim, a European product, and both have been on the market for some years. Bodlime is an American preparation, and has been used extensively for some time. The directions which are furnished with Bodlime advise first putting a band of tarred or sheathing paper eight inches wide on young or thin-bark trees, and then applying Bodlime to the band. Over 90 per cent., however, of the trees examined by us last summer on which Bodlime had been applied were those of the smooth-bark type, ranging from two inches to two feet in diameter, and in no instances were tarred or sheathing paper bands applied. In practically all cases this substance had penetrated the bark and injured the cambium layer. This injury, however, is in all probability not sufficient to kill the trees in every case; but more or less prominent effects will be left on the trees for some years, as evidence of the injury due to Bodlime. Some specimens of trees six inches in diameter were pointed out which were killed with Bodlime; and practically all the Carolina poplars located on the Fellsway, Malden, which have been treated with this substance, showed much injury to the cambium layer, resulting in prominent swellings on the trees where this substance had been applied.

A number of small white maples (two or three inches in diameter), which had been treated with Bodlime, appeared in two or three weeks to have an abnormal cambium layer, due to the penetration of the substance to the vital tissue. In all these cases Bodlime was applied directly to the trees, without paper bands. It should be noted, however, *that the manufacturers never intended that it should be applied to small or smooth-bark trees without first banding with tarred or sheathing paper, and the directions specifically state this.* When this is applied to large trees, however, without paper banding, it generally causes some subsequent slight disfiguration of the tree. We believe, however, that Bodlime constitutes a reliable banding substance, and can be applied to trees if the directions of the manufacturers are followed, — to first put on a band of tarred or sheathing paper. It should by no means be considered a reflection on the manufacturers if people will persist in ignoring the proper directions for applying the substance, as there is scarcely a remedy on the market which will not produce injurious effects if used injudiciously.

Anti-Moth. — This substance was used considerably in the summer of 1905 as a tree-banding material. It is a dark-colored, pasty substance, suggestive of wheel grease, and is applied directly to the bark. There were many instances observed where it was causing injury by soaking through the large, thick, rough-bark trees, as well as small, thin-bark ones. The trees which came under our notice had been treated only a few weeks with this substance, but our observations were sufficient to show that this constitutes a dangerous substance to apply directly to the bark of trees. Various small herbaceous plants banded with Anti-Moth died in a few days.

Eureka Tree Paste. — This substance as a banding material is not so universally employed as those previously mentioned, therefore our observations were limited in regard to its effects on trees. Moreover, this material, at the time our observations were made, had been on trees for only a brief period of time, consequently, the ultimate effects on the trees have not been observed by us. This substance resembles Anti-Moth, and is applied in the same manner. From the nature of the material, and its effects upon the stems of herbaceous plants, it cannot be recommended as a safe banding substance. Our experiments on herbaceous plants show that it is equally as injurious as the substance previously mentioned.

Raupenleim and Dendrolene. — These have been used as banding materials, although we have seen no authentic instances where they have been applied to trees in the vicinity of Boston during the past year. Raupenleim is a well-known German banding material, and Bodlime is supposed to be in many respects similar to it. Both, as far as we can learn, have about the same effects on vegetable tissue; that is, they injure it. Raupenleim was previously used by the Gypsy Moth Commission in large quantities. Dendrolene is an American product, apparently similar to Raupenleim in every way, both being crude petroleum products.

Razzle Dazzle. — During the past year our attention has been called to the use of a banding substance termed Razzle Dazzle, which has been employed to some extent on trees. This substance was sent in to us from one of the towns in the vicinity of Boston, with the report that it was doing damage to trees. We made a test of the substance on various herbaceous plants, and found that it killed them in a very short time. The substance appears to be made of resin, castor oil and some other oil-like petroleum which is injurious to vegetable tissue. We found that Razzle Dazzle has altogether too low a melting point. It commenced to run at about 90° F., and flowed freely at 100° F.

Bug Stop. — This substance is apparently made out of resin, oil and some form of grease, which causes injury to vegetable tissue. We found on testing this that it was very similar in its effects on tissue to Razzle Dazzle, and has a melting point ranging from 79° to 94° F. Besides the injurious effects which it has on vegetable tissue, it has a melting point entirely too low to make it a desirable banding substance.

Printer's Ink and Tarred Paper. — Printer's ink applied to tarred paper has been used to some extent for many years as a banding substance, and no ill results arising from its use have met our observation. We find this substance used extensively in the city of Medford on General Lawrence's estate.

Other Injurious Substances. — In one of the cities in the neighborhood of Boston crude petroleum or gas oil, such as is used in the manufacture of water gas, has been extensively used in spraying the trunks of trees for the purpose of killing gypsy moth eggs. This substance penetrates the bark very readily, and kills the vital layer. There are numerous instances where trees have been completely girdled, and have died in a very short time from the use of this substance.

Gas oil and creosote are used extensively for treating gypsy moth nests, and when mixed with lampblack they appear to cause little or no injury. Both of these substances are capable of causing injury to plants, either when used alone or when mixed with lampblack. We have not discovered any injury to trees from the use of these substances, however, when mixed with lampblack and used as a paint for the treatment of gypsy moth egg clusters. In one instance, where creosote and naphtha were applied with an atomizer to the trunks of trees covered with gypsy caterpillars, at the rate of 1 part of creosote and 5 parts of naphtha, the bark was rendered brittle and lifeless. At the time our examinations were made on these trees no injury had occurred to the cambium layer, but we should suspect that injury would later follow this method of treatment.

Some injury to trees often occurs from the use of kerosene, or kerosene and water together, when applied to the bark of trees. Kerosene and water have occasionally been applied to tree trunks for various insect pests by the aid of a certain mechanical mixing device. It should be stated, however, that these mechanical mixers are unreliable, and it is never safe to apply kerosene to trees, not even when mixed with water. The use of a gasoline blower or torch for the purpose of killing caterpillars has been in vogue to some extent. This should be condemned, since some injury has resulted from this practice. Scraping the bark too closely previous to applying a banding substance should be guarded against.

In conclusion, it may be said that Tanglefoot appears to be the only banding substance which we have tested that does not in any way cause injury to plant tissue, and that can be safely applied directly to tree trunks. Since this substance has a tendency to run at about 125° to 130° F., a slightly higher melting point would improve it. The manufacturers test this substance at 126° F., on a smooth, vertical surface, claiming that it will not run below that temperature; also, that some of their samples will not run below 130° F. They state that it will stand a little higher temperature on the bark of trees before it begins to run. Unfortunately, much of the Tanglefoot sent out by the manufacturers last spring was made on a different formula, and the melting point was entirely too low. It was sent back to the manufacturers, and modified according to a previous formula.

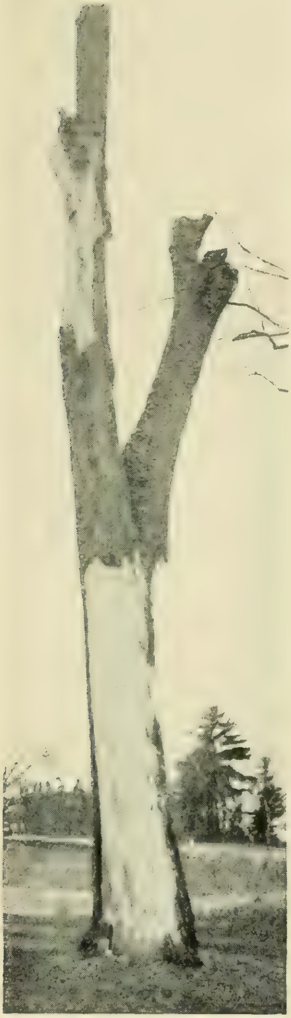
Such material as printer's ink, Bodlime, etc., can be safely applied to tree trunks in connection with tarred paper; and the latter can also be applied to rough, thick-bark trees without killing them, although even when used in this manner it will often produce some injury, which, however, may not prove fatal. We believe that it is essential, in applying any substance to a tree as a means of protecting it against insects, that one should be well within the limit of safety.

In this connection it should be noted that all of the manufacturers of these substances are, so far as we have learned, honorable business men, as is shown by their perfect frankness, and desire not to place any substance on the market which is not reliable. However, one should be cautious in purchasing newly advertised banding materials, since we have reason to believe that some of these new mixtures will not prove reliable. We have had opportunities to test a large number of new mixtures during the past two years, none of which, in our estimation, answers the requirements of a good, reliable banding substance.

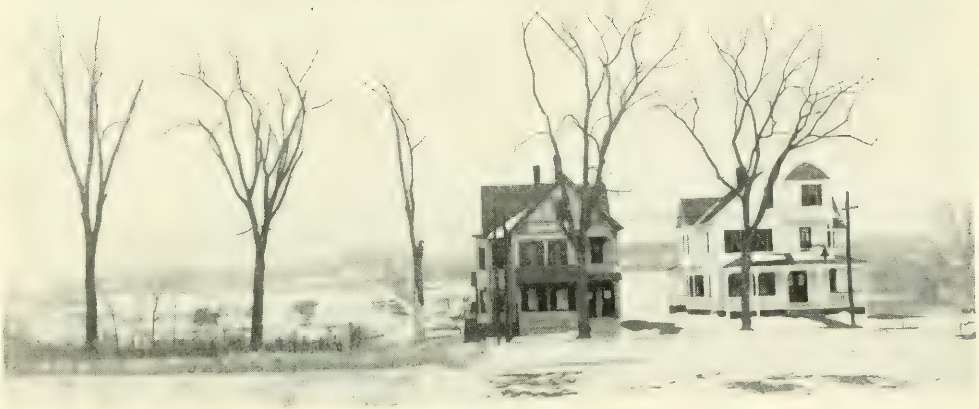
Effects of Escaping Illuminating Gas on Trees.

Undoubtedly a larger number of trees suffer from the effects of escaping illuminating gas at the present time than in previous years. The increased death rate from this cause may be accounted for by the fact that gas is now more extensively used than formerly, and the larger pipes now in use, together with modifications in the methods of laying these pipes and calking, may be in part responsible for the increased leakage. At any rate, it would seem that where small pipes have been in the ground for many years with thread joint connections there is much less leakage than where larger pipes are used, and where the calking is done with Portland or Roman cement and oakum or lead.

There is a large amount of gas manufactured by companies which is unaccounted for. According to the twenty-first annual report of the Gas and Electric Light Commissioners of Massachusetts, the production of gas for the year 1905 in this State was 6,418,024,954 cubic feet. The amount unaccounted for during that year was 622,304,044 cubic feet; in other words, there was a loss of about 10 per cent. Probably this loss represents more than mere leakage, since part of it may be accounted for by differences in temperature which the gases are subjected to when measured. Nevertheless, there



Showing effect of illuminating gas on elm tree, one and one-half years after leakage occurred. (From "Park and Cemetery.")



Large elms killed by escaping illuminating gas, one and one-half years after leakage occurred. (From "Park and Cemetery.")

is a very large number of leaks in gas mains at the present time, and the number of cubic feet of gas which annually escape into the soil is quite large.

There are a great many joints in gas mains from which can be detected only slight leakage, — perhaps from two to three cubic feet a day; whereas there are others from which the leakage is very extensive, and from which thousands of cubic feet of gas escape into the soil in the course of a year. Even these smaller leaks, where the outflow is only from two to three cubic feet a day, are capable of injuring trees in the course of time, since the soil becomes charged with gas to quite an extent in a few years. Should the roots of trees happen to be near these leaks, the trees will become unhealthy, but perhaps will not die. There are hundreds of city trees affected in this manner, and gas is seldom suspected of causing their sickly condition. In the eastern States, at least, there are three kinds of gas used, — water gas, coal gas and oil gas. So far as the effects of these various gases on trees are concerned, there is apparently little or no difference, since they all contain similar elements which are poisonous to trees.

There are two classes of injury which may readily be distinguished as resulting from gas poisoning: first, incipient cases; and second, pronounced cases. In the first series we have those already alluded to as resulting from small leaks, and the ground in such cases never becomes fully charged for any considerable distance. They may not result in killing the tree directly, but cause it to be unhealthy, and there is likely to be a large amount of dead wood found on such trees annually. Occasionally a large tree may be located near a small leakage, and in such a case only a single root will be affected. Those portions of the trunk of the tree in direct connection with the leak will, however, show the effects of gas poisoning. Small leaks of this description often produce only local injury. Trees affected in this manner may suffer with what is termed "general debility," — a term often used to cover up a vast amount of ignorance concerning diseases in general. In severe cases of gas poisoning, such as take place where there is a large leak, the effects on a tree are very pronounced, and there is absolutely no hope of recovery for a tree which has once been severely injured by gas; in short, where a tree has been defoliated or even half defoliated from the effects of gas, there is no hope for it, although it might be possible, if one could dig up all the soil around it and expose it to the air, to eliminate much of the gas in the soil, in which case the tree might make some attempt to recover.

The characteristic symptoms of gas poisoning are quite marked to one familiar with them, and can generally be distinguished from other kinds of injury which are likely to affect a tree. It requires, however, pretty close observation and thorough understanding of conditions in order to distinguish gas poisoning from some other types of injury which may occur. For example, in the gypsy moth district about Boston the trunks of many trees have been treated with crude oil and various other substances which are exceedingly injurious to trees. Crude oil or kerosene, when sprayed on the bark of a tree, will penetrate the wood to some extent. Unless one is perfectly familiar with the characteristic symptoms of trees poisoned with gas, it would be a very easy matter to confound these two classes of injuries. In both cases the bark becomes loose and falls off the tree very quickly. From careful observations of the trunks of trees, however, the effects of crude oil can generally be distinguished from those caused by gas, by one who is familiar with these characteristic injuries.

In general, however, the symptoms shown by trees affected with illuminating gas are quite different from those arising from other causes which are likely to be active. Trees affected with gas are very susceptible to rapid disintegration. One of the first effects of poisoning in summer would be a yellowing and drying up of the foliage, and a greater or less defoliation of the tree, according to the degree of poisoning. The trunk of the tree is generally dark colored, indicating an absence of life; but this feature is not always present.

The occurrence of various species of fungi on trees affected by gas is rather conspicuous, since these fungi are often very numerous, and make their appearance soon after a tree has been injured; whereas on trees dying from other causes it is sometimes many years before the bark becomes covered with fungi. The sap wood is often found to be discolored, and it has peculiar, characteristic odors which assist in a diagnosis. Sometimes, however, especially when the tree is injured by gas in late summer, at which time the flow of sap is not so pronounced as in the spring, the odors of the wood are not so marked.

The writer has had many years' experience in examining trees injured by illuminating gas, and has had occasion to study a large number of them each year. In our diagnosis of such trees we make use of a small hatchet, which is employed to cut into the trunk of a tree for the purpose of examining the tissue. In most cases it is only necessary to insert the hatchet into the trunk and gradually pull the tissue back to see whether it is normal or abnormal. Little injury is done to the tree by this practice, as a mere slit in a healthy tree will heal over in a short time. In other cases it is necessary to take out a chip and examine the tissues under a microscope. An examination, by means of a hatchet, of the larger roots which extend above the surface of the soil, causes less disfigurement, and the source of leakage, if such is present, may be discovered. The escape of gas into the soil from a leak follows the line of least resistance. For this reason, if leakage occurs in the street in front of a house one can usually detect the odor of gas in the cellar, as the gas will follow the exterior of the pipe leading into the cellar.

There is considerable difference in the resistance of soils to gas. In gravelly soils we have known gas to travel 2,000 feet without any difficulty when the ground is frozen, and escape into the cellar of a house; whereas in heavier soils gas is more likely to be restricted to smaller areas.

The poisonous properties of gas undoubtedly consist in the coal tar products, which contain such compounds as sulfates, cyanides, etc. Gas escaping into the soil probably condenses fully as rapidly as in the pipe. The gas-drip which is taken out of a pipe is the condensed portion, and this in itself is very rank in odor and extremely injurious to plants, whether the volatile products are taken in through the leaves or the liquid through the roots. It is apparently these condensed products which are taken up by the roots and which poison the tree. About 1 or 2 per cent. of gas is absorbed by water, and the water in the soil becomes charged to a certain extent with gas. In the course of time, where the leakage is more or less extensive, the odor of the soil becomes extremely obnoxious. This odor disappears very quickly when the soil is aerated; in fact, when a gas leak is found it is an excellent idea to leave the ditch open for a few days, to get rid of the strong odors which are present in the soil. There is a certain capacity of adaptation of plants to poisons, and this probably exists to some extent in the case of trees; but this capacity is limited, and where the leakage of gas is continuous, the roots are sure to be poisoned in time. The writer has treated various small trees and plants with gas, and has grown plants in water charged with it. Gas, like many other poisons, acts as a stimulus to plants at first, but eventually kills them. It is possible, however, to keep roots alive in water charged with gas every twenty-four hours for a considerable length of time. Finally, however, after the plant has absorbed a certain amount the cambium layer is affected, and disintegration takes place rapidly. It requires a considerable amount of gas to kill a large tree, but it must be borne in mind that the conditions surrounding a tree are favorable for maintaining gas in the soil for a long time. Mr. H. A. Ballou, one of our former students, treated a large maple tree with 1,000 cubic feet of gas. This was done by digging a hole in the ground under the feeding roots to a depth of four feet or more, and the gas was allowed to escape into the soil at this point for a number of months. The result was that not the slightest injury was done to the tree. If, however, the same amount of gas had been allowed to escape near a tree located on a macadamized road, and the leakage had extended over a period of two years instead of three or four months, some injury would have been discernible.

Many gas companies now openly recognize the fact that a certain amount of gas leakage occurs continually, and that a certain number of trees are likely to be killed each year; therefore, they endeavor to settle all claims for damages to trees arising from gas out of the courts. In Massachusetts the court has decided in more than one instance that a good-sized, well-developed and sound tree in front of an estate is worth from $150 or $200 in the valuation of that property; and if such a tree is killed by gas, the abutter is entitled to damages. In most of the cases of gas poisoning the companies have settled with the abutters, allowing anywhere from $5 to $150 a tree. In other States courts have decided that an owner of land which abuts on a city street and which is planted with shade trees is entitled to have such trees protected against negligence or wilful destruction at the hands of a third party. A large, handsome tree taken from a well-kept avenue is a greater loss to the abutter's property than a similar tree on a poor, ill-kept street. Moreover, a tree half-killed by the teeth of horses is not worth as much as one in good condition. In some cities gas companies have settled with the city for the loss of trees.

According to tree laws in Massachusetts, gas companies are undoubtedly subject to a fine for injuring or causing the death of a tree, in addition to the damages for causing a deterioration of property owing to the loss of such trees, since the laws relating to injuries to shade trees are explicit. In some cases the abutter is satisfied if new trees are planted to replace the old ones.

Undoubtedly much of the loss arising from gas the past few years has been due to inferior work in laying pipes. In one small city, where four miles of pipe were laid, we were able to find one hundred trees which were injured beyond recovery from gas poisoning, two years after the gas mains were laid; and we venture to say that three or four hundred other trees in the same locality were more or less affected by gas, many of which will subsequently die a premature death.

Germination and Growth in Soils of Different Texture.

It requires only a casual glance at the flora of any region to note the fact that soil texture plays an important part in the distribution and adaptation of plants. Soil, however, is so intimately connected with and modified by other factors, such as organic matter, arrangement of the particles of the soil, chemical constituents, the presence of living organisms and differences in the amount of water, that it is a most difficult problem to determine accurately the role which texture alone plays in plant distribution and adaptation.

Humus is undoubtedly closely associated with certain ecological features connected with the life history of plants, since it furnishes an environment for various micro-organisms which in some instances amount to many millions per gram; and if the behavior of these organisms in culture media furnishes a criterion for their activity in soil, important chemical changes must take place.

In endeavoring to account for the distribution of any particular species of plant, one is confronted with a complex problem, since there are various influences responsible for distribution, and the elimination of these factors is beset with difficulties.

In some cases differences in the degree of adaptability of plants appear to exist corresponding with their stages of development; for example, a seedling will die in a soil of certain texture, when a more mature plant of the same species will succeed in thriving to a greater or less extent.

Soil texture exerts an influence upon the configuration of plants which may be seen even in restricted areas; for example, certain soils are especially adapted to the luxuriant development of elms, and such soils exert a marked influence not only upon the general type of tree, but the color, size and texture of the leaves, — a feature which may be seen to a similar degree in other native plants.

Among our well-known cultivated plants there are some which are influenced to quite an extent by soil texture, the best known among these being tobacco. Since the texture, aroma and color of the leaf is tested many thousand times daily by smokers, much knowledge has been gained regarding the influence of soil texture and other factors upon the growth of this crop. It is well known that the crops from some soils sell for two and three times as much as those grown on soils of a different texture. In the development of head lettuce soil texture also plays an important role. This type of lettuce is largely grown on the Atlantic coast soils, which predominate in the coarser grades of sand. When head lettuce is grown in finer-texture soils it does not head up well, and little or no attempt is made to grow this crop in soils of this nature. Lettuce seed sown in a soil of fine texture will not germinate nearly as well as in loose soil, and lettuce seedlings will reach a certain stage of development, remain stationary for weeks and eventually die. The reason why a fine-texture soil prevents seedlings from developing is lack of air. This may be illustrated by the more vigorous growth which lettuce seedlings make in such a soil near the edge of a flower pot than in the middle, and by various soil aeration experiments.

The compactness of a soil, as might be expected, exerts an influence upon germination and growth. The following table shows the effect of loose and tamped loam and subsoil upon the germination of seeds. In one case a good loam, containing about 8 per cent. of organic matter, was employed, one box being tamped very firmly with a heavy weight after the seeds were sown, and the other left very loose. In the other case two boxes of soil of fine texture (subsoil) were employed. This soil was very deficient in organic matter. These two boxes were treated in a similar way to those containing loam; that is, one was left very loose and the other tamped firmly after the seeds were sown. In all the boxes very little soil was placed over the seed.

Result of Seed Germination in Loose and Tamped Soils.

	LOAM.		SUBSOIL.	
	Loose.	Tamped.	Loose.	Tamped.
Lettuce, 200 seeds,	75	–	51	–
Rattlebox, 200 seeds,	80	22	33	7[1]
White clover, 400 seeds,	146	7	45	–

[1] The seedlings came up in cracks in the soil.

No lettuce seed germinated in the tamped loam or subsoil, while white clover made its appearance in the tamped loam. Rattlebox, which with us is quite at home in fine-texture soil lacking organic matter, did better than the lettuce or white clover. None of the seed possessed a high percentage of germination, and some allowance must be made for this. All of the seed germinated better in the loose loam than in the loose subsoil, and the rattlebox and white clover showed greater capacity for adaptability to tamped soil than the lettuce.

Lettuce is remarkably susceptible to lack of soil aeration, as is shown by the many experiments we have made with this plant. The following table shows the effect of soil texture upon the germination and growth of lettuce. The boxes employed in this experiment were eight inches square, and each was nearly filled with carefully sifted coal ashes, containing particles corresponding to the sizes given in the table. Each box was weighed and watered daily, and the amount of water applied was such that the degree of saturation was equal to one-half the water-retaining capacity.

Influence of Soil Texture on the Germination of Lettuce Seeds and Growth of Seedlings.

	Size of Particles (Millimeters).	Per Cent. of Germination.	Average Weight of Seedlings (Milligrams).
Box 1, ...	2-1	54.2	40-60
Box 2, ...	1-.5	38.0	80-84
Box 3, ...	.5-.25	24.8	59.99
Box 4, ...	.25-.1	33.0	41.45
Box 5, ...	.1-.0001	14.2	19.25

The preceding table includes the results of three experiments, in which 3,000 seeds were employed. The highest percentage of germination is given by the seeds sown in ashes containing particles having a size of 2–1 millimeters; while the largest average weight of the seedlings is shown by those which were grown in ashes containing particles having a diameter of 1–.5 millimeters. In the case of some experiments in similar boxes with sand the highest percentage of germination took place in the particles ranging from .5 to .25 millimeters; and the largest average weight of seedlings was given by the particles ranging in size from 1 to .5 millimeters, or the same as in the experiment with ashes. It should be pointed out that important differences exist between coal ashes and sand in respect to absorption of moisture. This was quite noticeable in the experiments, inasmuch as the ashes act like a sponge and water is retained to quite an extent by them; while in the sand no such absorption takes place, as is readily shown by the top layers of the coarse sand becoming dry, — so much so at times that seed germination was seriously interrupted. For this reason it was impossible to maintain the same relative degree of moisture in the various strata in the sand boxes as in the ashes. Since ashes were more porous and spongy, the difference in the amount of moisture in the various strata was less marked, and there was no difficulty in maintaining enough moisture for germination in the coarse particles of coal ashes.

The influence of variation in the soil moisture cannot be eliminated in comparative experiments with soils of different texture, since the capillarity of the different grades of soils is by no means the same; neither is the amount of water which the seeds and seedlings received under these conditions identical.

Some parallel experiments were undertaken in shallow plates, containing about three-fourths inches of coal ashes, having the same range in the size of particles as in the previous experiment, with somewhat similar results. In the plate experiments the difference in the amount of moisture due to the difference in the capillarity was considerably modified, since the substratum was so shallow that the seedlings, after they had become mature to a certain degree, could obtain practically the same amount of water from each type of particles, providing evaporation was checked, thus preventing stimulation which would arise from the difference in the water supply, although the water in the plates containing the coarse particles would be more largely confined to the lower strata. Soil texture and water supply are intimately associated, and this has led some to believe that water constitutes the ruling element in the soil in crop production. Respiration is also an important function in plants, for which process oxygen is necessary. When plants are deprived of oxygen they cease to grow, and seeds will not germinate.

It is important that roots be supplied with air for respiration, as is shown by aeration experiments; and in the experiments with lettuce the difference in the percentage of germination and growth of seedlings in ashes was determined by differences in the air supply furnished by the various grades of particles employed.

TEXTURE OF MASSACHUSETTS SOILS.

For some years this department has made mechanical analyses of soils in connection with the study of problems relating to greenhouse crops, and for various persons who desire to know the constituents of some particular soil. A list including some of the analyses is presented with this report, the soils being grouped in a general way under different headings.

In the list of soils which follows, acknowledgment should be made to those who have taken part in this work, most of whom have been from time to time students and assistants in our laboratory. Some of these soils were analyzed by Mr. Asa S. Kinney, now director of the Botanical Gardens at Mount Holyoke College; others by Messrs. A. A. Harmon, A. C. Monahan, A. L. Dacy, E. H. Scott, L. K. Liang; and particularly Mr. N. F. Monahan, assistant in the laboratory, who has made by far the greatest number of these analyses.

The methods employed are those recommended by Dr. Milton Whitney. In some of the earlier samples the finer-grade material was separated by the gravity method, while all the later analyses have been made by the centrifugal method of separation. In all cases 20 grams of soil were used in each analysis.

The soils best adapted to general market gardening are those which contain considerable proportions of coarse material, which render them loose and friable. Such soils predominate near the coast, and excellent types may be found in many of our river valleys. The soils about Boston, especially those in Arlington, Belmont, Newton, Bedford and Concord, are exceptionally well adapted to market-gardening purposes, and some of the best crops in the United States are raised in these towns. Market gardening has been carried on in the above-named localities for many years, and remarkable skill has been developed in handling certain crops. This statement holds true not only in general truck farming, which is followed to a large extent in these regions, but is especially applicable to the cultivation of head lettuce under glass, in which unique skill has been developed.

It is not unusual for market gardeners to put 40 cords of horse manure per acre on the land used for market-gardening purposes, and to a soil devoted to greenhouse lettuce even larger quantities of manure are applied. In general, the best market-gardening soils are those which contain a large amount of coarse material, which is well illustrated by the Belmont, Newton, Concord and Bedford soils. (*Cf.* Table I.)

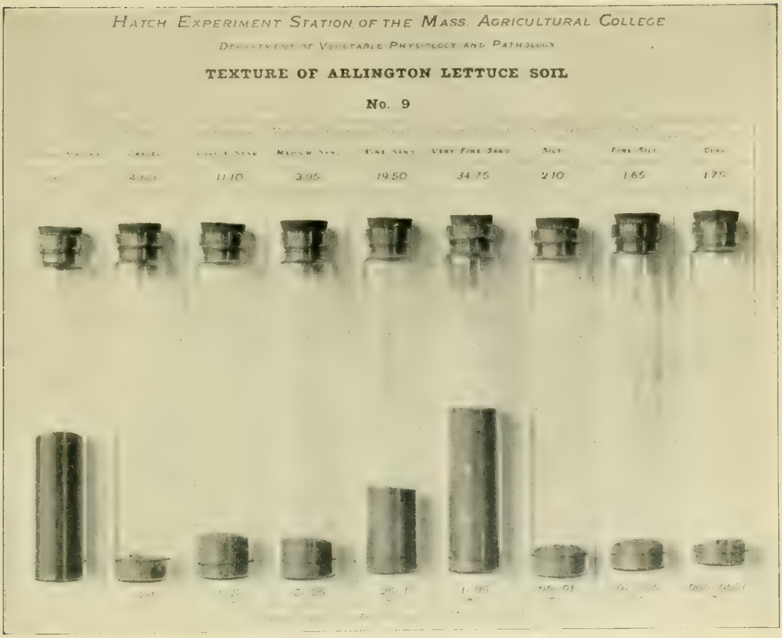
In a similar class may be included Worcester soil No. 10, New Bedford, Swansea and Touisset. The Worcester soil No. 10 is from a river valley, and is well adapted to the growth of head lettuce. The Providence soil is quite similar to those of Cape Cod, and is somewhat coarser than the Arlington and Belmont types. When these coarser soils are well supplied with organic matter they are suitable for lettuce. The Worcester soils Nos. 13 and 20, together with the Amherst, Huntington and Pittsfield soils, are not desirable ones for head lettuce, since they are too compact. These soils, however, have been used for lettuce, and for this reason are included in this list.

TABLE I. — *The Mechanical Analyses of Some Market-garden Soils.*

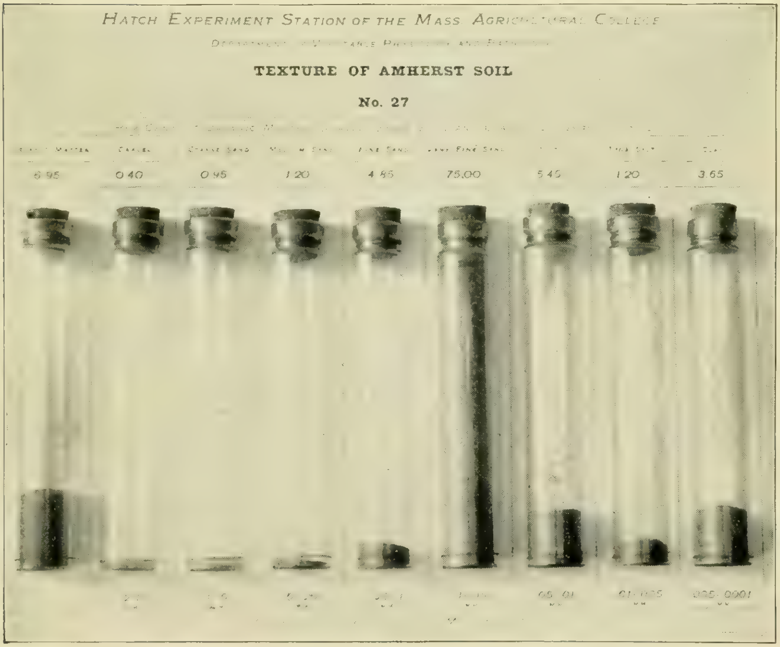
[Diameter of the grains in millimeters (1 millimeter equals about 1/25 of an inch); gravel, 2–1; coarse sand, 1–.5; medium sand, .5–.25; fine sand, .25–.1; very fine sand, .1–.05; silt, .05–.01; fine silt, .01–.005; clay, .005–.0001.]

Station Number.	LOCALITY.	Water-retaining Capacity.	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
6	Pittsfield, . . .	50.00	11.50	5.35	5.00	4.80	14.00	37.00	7.05	1.20	6.95
9	Belmont, . . .	51.30	10.00	4.60	11.10	3.95	19.50	34.75	2.10	1.65	1.75
14	Subsoil of No. 9, .	29.30	1.80	2.85	8.25	14.30	32.20	32.05	2.30	1.30	2.35
10	Worcester, . . .	46.20	9.01	7.17	15.40	10.10	15.30	29.54	9.85	2.87	2.07
13	Worcester subsoil, .	41.00	9.60	1.40	2.00	3.95	20.70	43.45	7.20	3.05	3.60
15	Newton, . . .	67.90	15.18	5.75	8.12	7.07	12.06	34.01	2.10	0.20	3.82
16	Spencer, . . .	50.00	9.80	2.70	4.55	7.30	22.35	29.60	6.65	2.45	3.25
17	Providence, R. I., .	39.60	6.65	9.20	17.85	16.85	20.90	22.50	2.75	0.40	2.25
18	Pittsfield, . . .	61.00	11.00	5.65	6.90	5.25	13.75	35.30	5.95	0.55	3.85
19	New Bedford, . .	40.00	7.60	4.10	5.45	6.45	12.00	39.45	6.95	5.50	5.55
20	Worcester, . .	45.10	9.40	1.65	2.80	4.25	19.85	42.95	4.50	2.95	2.75
21	Worcester subsoil, .	36.50	2.80	1.00	1.20	1.10	8.30	66.45	7.35	2.10	5.35
22	Amherst, . . .	40.50	6.00	2.60	5.90	7.90	15.40	40.75	9.25	2.60	4.65
44	Huntington, . .	43.20	8.00	0.36	0.90	1.32	10.09	29.40	27.38	6.35	7.93
47	Concord, . . .	46.59	7.80	5.45	11.01	13.95	25.03	17.87	12.38	0.99	2.75
52	South Sudbury, .	59.93	9.40	2.59	5.79	7.93	25.19	26.38	12.74	2.45	0.98
57	Bedford, . . .	67.21	12.64	3.80	5.30	5.40	15.02	22.91	19.63	7.34	3.37
65	Waltham subsoil, .	54.01	4.32	0.83	1.58	1.94	10.82	44.81	21.15	4.49	7.25
77	Belmont, . . .	42.66	13.20	3.18	5.85	12.13	37.34	14.12	3.60	0.59	1.73
89	Swansea, . . .	61.80	10.44	4.80	5.07	13.19	21.72	22.88	14.60	1.36	3.49
95	Touisset, . . .	51.30	11.66	2.37	3.59	13.63	19.44	32.39	13.22	0.79	1.64
97	Belmont, . . .	50.00	10.57	6.49	5.84	10.49	11.65	30.25	9.33	4.78	4.01

The greenhouse cucumber soils given in Table II. are from widely separated localities, and, with the exception of the organic matter which they contain, are no better adapted to the growth of cucumbers than soils which may be selected from other places. One special feature, however, in connection with these soils is the large amount of organic matter which they contain, which greatly modifies their texture. Most greenhouse soils are rich in organic matter, which is furnished by the extensive use of horse manure and de-


HATCH EXPERIMENT STATION OF THE MASS. AGRICULTURAL COLLEGE
DEPARTMENT OF VEGETABLE PHYSIOLOGY AND PATHOLOGY
TEXTURE OF ARLINGTON LETTUCE SOIL
No. 9
Gravel
Medium Sand
Fine Sand
Very Fine Sand
Silt
Fine Silt
Clay
4.60
11.10
3.95
19.50
34.75
2.10
1.65
1.75
.05-.01

An ideal market-garden soil.



Not well adapted to market gardening.

composed sod. Cucumbers are not so susceptible to soil texture as lettuce, since almost any soil fairly well provided with organic matter is suitable for their growth; while in the cultivation of head lettuce it is necessary to have, in addition to a good supply of organic matter, a certain percentage of the coarser particles of soil.

The best method of preparing soil for cucumbers consists in mixing one-third horse manure, one-third loam and one-third sod. These constituents form a suitable basis for a good cucumber soil, and by the extensive use of horse manure each year it can be kept in good condition.

TABLE II. — *The Mechanical Analyses of Some Cucumber Soils.*

Station Number.	LOCALITY.	Water-retaining Capacity.	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
34	East Brookfield, .	50.66	6.00	7.80	21.18	18.57	17.01	21.96	2.89	2.18	2.25
74	Athol, ...	57.30	22.46	8.71	12.80	7.33	12.39	8.85	13.21	2.59	1.39
75	Lincoln, . . .	57.00	11.00	2.36	6.18	7.87	24.66	29.89	13.33	0.83	3.14
76	Fitchburg, . . .	42.70	26.02	2.71	7.91	6.45	13.05	12.64	18.33	3.36	1.33
94	Beverly, . . .	66.40	12.13	6.21	6.94	12.26	10.97	29.48	15.32	1.55	1.39

Asparagus is usually grown on a coarse, sandy soil, generally deficient in organic matter, partly for the reason that such soils will not grow anything else satisfactorily. It by no means follows, however, that asparagus requires this type of soil, since, as a matter of fact, the best beds in the State are located on soil of finer texture than most of those shown in Table III.

Such soils as Nos. 33 and 73 possess finer textures than others, and they are excellent asparagus soils, besides having the advantage of growing crops which are not subject to the summer stage of the rust; whereas plants grown in coarse soils are often severely attacked by the rust, regardless of their location. The most important feature connected with asparagus soil in respect to texture is its ability to supply water during periods of excessive drought, which enables the plants to resist outbreaks of rust. In some cases asparagus beds will yield $1,000 per acre.

TABLE III. — *The Mechanical Analyses of Some Asparagus Soils.*

Station Number.	LOCALITY.	Water-retaining Capacity.	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
1	Eastham, . . .	38.99	2.00	9.38	27.91	25.09	21.43	8.70	1.40	0.77	1.44
7	Orleans, . . .	35.28	2.20	20.97	31.03	19.70	12.26	6.26	2.77	1.46	1.37
8	Concord, . . .	49.81	4.19	4.24	10.20	12.81	27.93	34.11	1.84	1.79	1.08
32	Subsoil of No. 8, .	33.66	1.77	9.69	12.75	11.80	19.23	24.30	14.70	2.24	0.78
30	Attleborough, . .	48.76	7.54	9.26	11.15	7.87	11.53	29.57	10.95	2.52	1.42
31	Montague, . . .	33.46	2.74	0.18	2.75	14.77	23.30	44.39	6.16	1.16	3.27
33	Montague, . . .	48.71	1.86	0.27	4.39	19.86	43.88	25.75	2.64	0.36	0.14
45	Concord, . . .	42.95	12.60	6.90	12.03	10.88	21.43	15.44	6.00	5.50	2.98
46	Concord, . . .	32.82	3.20	0.73	2.69	5.69	31.73	37.84	4.48	1.30	4.30
48	Longmeadow, . .	27.34	2.80	3.52	14.88	15.90	25.48	21.60	5.46	1.21	4.31
53	South Sudbury, .	33.64	3.38	0.65	3.22	9.18	40.27	30.29	2.47	1.75	1.99
55	South Berlin, . .	29.54	2.30	5.33	17.70	10.13	11.98	14.08	23.43	4.49	3.58
73	South Deerfield, .	34.00	1.68	1.33	6.76	22.68	31.12	18.41	6.89	1.53	3.49
2	Eastham, . . .	37.13	2.60	17.93	28.80	18.85	5.80	19.15	2.85	1.34	0.66

The soil of the Connecticut valley may be described as loam, predominating in fine sand and silt, and is quite different from soils found in other parts of the State. (*Cf.* Table IV.) It is remarkably free from stones, and well adapted to the growth of onions, tobacco, pickle cucumbers and various other crops. In some parts of the valley, where the soil is mixed with coarser material, good greenhouse lettuce is grown. The most important crops, however, are onions and tobacco, and the former crop is considered better than that raised in any other part of the State. Dr. Milton Whitney, chief of the Soil Bureau, who has investigated and mapped the Connecticut valley soils, implies that they are not so well suited to the growth of the best quality of tobacco as some of the types of Connecticut soil, but they yield heavily, which enables the tobacco grower to derive considerable income from this crop.

There is an opinion prevailing among farmers that some of the Connecticut valley soils are better adapted to the growth of onions than tobacco. The greater proportion of both crops is grown on what Dr. Whitney terms "Connecticut meadow" and "Podunk fine, sandy loam;" and we cannot say whether onions require, for their best development, soil differing very materially in texture from that required for tobacco.

TABLE IV. — *The Mechanical Analyses of Some Tobacco and Onion Soils.*

Station Number.	LOCALITY.	Water-retaining Capacity.	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
11	Hatfield, . . .	33.33	3.78	0.05	0.13	0.30	3.38	60.35	26.29	0.71	4.34
12	Sunderland, . .	37.80	6.76	0.03	0.25	0.50	3.92	21.87	47.86	14.70	2.71
54	North Hatfield, . .	63.38	5.73	0.03	0.20	0.25	6.30	37.87	32.85	5.13	5.01
58	Sunderland, . .	32.38	4.72	0.13	3.32	0.43	5.83	52.18	23.40	2.12	1.54
59	Easthampton, . .	31.18	4.40	0.07	0.42	0.75	10.84	62.43	7.51	0.41	1.03
61	Hadley, . . .	38.78	5.32	0.05	0.28	0.33	1.08	51.46	24.01	7.75	7.00
62	Subsoil of No. 61, .	36.23	4.65	0.08	0.41	1.76	11.32	56.56	17.56	4.25	1.03
63	Double subsoil of No. 61.	34.77	2.40	0.56	0.33	4.98	2.33	50.68	18.80	11.33	6.36
70	Sunderland, . .	65.50	8.22	0.10	9.45	1.44	4.35	40.01	29.67	0.46	5.65
78	Whately, . . .	50.00	10.34	1.65	3.42	12.66	36.29	11.24	14.69	0.59	0.79
90	Whately, . . .	49.30	8.17	1.20	2.29	12.37	35.29	21.39	15.44	0.68	1.49

There is no greenhouse specialty which requires so much skill as the growing of roses, and the magnificent specimens which may be found in the markets at almost any season of the year surpass all other greenhouse products in beauty and perfection. There is no plant which requires so heavily manured a soil as the rose. The customary formula for mixing such a soil is one-third finely pulverized sod, one-third loam and one-third cow manure. In addition to this, some form of commercial fertilizer is occasionally applied. Watering the plants with a strong decoction of cow manure is frequently practised.

It is highly impracticable to use a soil of this nature for two consecutive seasons, since, owing to its high state of fertilization and the subsequent chemical changes which take place in the soil, a toxic effect is produced upon the plants. No class of greenhouse specialists is more particular about the texture of the soil employed than rose growers, especially when growing the American Beauty. American Beauties are more susceptible to differences in soil texture than other varieties of roses, and a perfectly satisfactory soil for their growth has not as yet been found in this State. They require soil of a different texture from Brides and Bridesmaids.

The rose soils in the list (*Cf.* Table V.) were obtained from various sources, some of which are noted for their production of excellent roses; while others are prospective rose soils, — that is, soils sent in by rose growers who wished to ascertain whether they were well adapted to the growth of roses. It will be noticed that most of these analyzed rather high in very fine sand and silt, while two of the samples contained nearly 10 per cent. of clay.

TABLE V. — *The Mechanical Analyses of Some Rose Soils.*

Station Number.	LOCALITY.	Water-retaining Capacity.	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
3	Natick, . . .	43.50	9.20	4.50	6.55	6.30	13.22	32.17	5.67	1.18	9.17
29	Madison, N. J., . .	52.10	9.96	3.87	7.10	8.10	13.77	26.77	8.85	1.20	9.40
35	Clifton, N. J., . .	64.30	7.90	3.60	13.50	18.77	17.83	23.30	8.59	1.66	3.53
43	Tarrytown, N. Y., .	54.06	8.10	.19	3.00	4.58	13.69	22.88	22.25	11.25	5.94
67	Amherst, . . .	56.50	8.96	3.51	3.25	3.87	9.75	45.42	14.49	.99	3.86
79	Westborough, . .	49.20	6.06	3.21	3.13	6.92	8.80	35.81	21.14	.99	4.31
81	Subsoil of No. 79, .	34.00	3.86	5.05	3.41	7.60	13.83	38.90	19.64	.73	3.77
82	Westborough, . .	60.24	6.99	3.07	3.23	7.77	9.25	47.81	16.28	.40	1.22
80	Subsoil of No. 82, .	36.00	3.88	5.52	4.61	9.29	13.36	26.12	26.25	.87	3.87
84	Westborough, . .	42.00	8.96	4.59	4.29	9.18	13.35	22.04	26.70	1.97	2.87
85	Natick, . . .	57.90	9.10	4.76	4.00	9.61	15.08	25.57	25.55	.90	1.48
86	Subsoil of No. 85, .	33.50	3.57	7.41	6.20	14.70	18.80	25.83	9.97	11.06	1.17
88	Natick, . . .	48.00	6.02	4.73	4.19	9.80	15.74	30.00	21.75	1.41	2.59
87	Subsoil of No. 88, .	60.25	4.71	4.35	3.58	8.36	11.25	33.77	26.47	1.04	4.01

Throughout Massachusetts there are many hills of an oval shape, whose long axes run in a northerly and southerly direction. These "clay hills" are designated "drumlins" by geologists, and in some parts of the State, notably on the ridge passing through Worcester county, they are abundant and symmetrical in outline, forming the most picturesque part of the landscape.

While these are commonly termed "clay hills," their surface soil cannot be classed as such, although it is a heavy, rather cold soil, especially adapted to the growth of some of the coarser grasses, like timothy. They make excellent pastures for cattle, and many of the best dairies in the State are located in regions where these hills prevail. (*Cf.* Table VI.)

Drumlins were formerly much valued by the Indians for agricultural purposes, since historical research reveals that many of them were cleared of forest growth at the time of the first English settlement in New England. They are well supplied with water, as is shown by the fact that crops grown on them seldom suffer from drought. They are largely cleared of forest growth to-day, because they are now, as in early times, highly valued for agricultural purposes. The original growth of trees consisted of chestnut, and where forests exist on these hills at the present time they consist mainly of this species.

TABLE VI. — *The Mechanical Analyses of Some Drumlin Soils.*

Station Number.	LOCALITY.	Water-retaining Capacity.	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
4	Spencer, . . .	40.70	8.50	5.32	6.80	8.88	21.96	32.51	8.07	2.02	3.05
49	Southbridge, . .	44.05	7.44	6.55	9.20	4.23	23.53	22.36	15.90	3.92	5.12
50	Subsoil of No. 49, .	33.30	3.20	5.98	8.18	6.07	15.78	16.84	19.60	13.05	6.23
51	Subsoil of No. 49, .	26.60	2.74	5.43	10.21	11.78	16.73	19.83	18.80	9.05	.39
83	East Brookfield, .	35.25	6.97	8.67	6.53	11.93	16.55	21.33	18.98	1.59	3.90

Of the remaining soils, a variety of types are represented. (*Cf.* Table VII.) A large number of these were taken from the experiment station grounds, and they predominate in very fine sand, which causes the soil to become quite compact when wet. They resemble the general type of Connecticut valley soils, and are not well adapted to the growth of greenhouse crops. The Oxford soil is from a river valley, and is suitable for truck farming. Soil No. 96 is from the Berkshire hills, and No. 56 from a Worcester county town, with an elevation of approximately 1,000 feet.

The analysis of earthworm castings is similar to that of the soil in which the earthworms live, with the exception of a small amount of organic matter.

TABLE VII. — *The Mechanical Analyses of Some Miscellaneous Soils.*

Station Number.	LOCATION.	Water-retaining Capacity.	Organic Matter.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Fine Silt.	Clay.
5	Amherst experiment station.	68.45	7.32	.95	1.05	1.72	7.29	66.19	6.96	1.33	4.13
25	Amherst experiment station.	35.40	7.00	.25	.65	.90	4.45	74.15	5.01	.65	4.05
23	Amherst experiment station.	42.50	8.60	2.80	1.80	3.05	10.70	50.95	6.70	2.35	6.50
24	Amherst subsoil, .	31.33	3.60	1.75	4.45	6.95	23.85	35.95	11.10	5.20	5.25
26	Amherst experiment station.	32.33	6.72	.35	.81	1.73	9.15	64.69	10.70	1.13	2.35
27	Amherst experiment station.	33.66	6.95	.40	.95	1.20	4.85	75.00	5.45	1.20	3.65
28	Amherst experiment station.	50.00	9.36	3.10	6.08	4.86	3.81	57.87	2.61	1.46	.73
36	Oxford, . . .	66.70	7.30	7.95	8.45	5.28	6.54	44.34	12.13	2.26	1.11
37	Amherst experiment station.	36.33	2.24	.34	4.03	5.03	6.64	74.42	1.98	.73	2.40
38	Earthworm castings.	67.76	9.60	2.10	7.51	7.45	13.40	39.26	12.13	3.21	1.79
39	Marshfield, salt marsh.	81.66	17.90	.00	.27	1.95	10.37	32.01	13.40	9.87	10.07
40	Marshfield, salt marsh.	81.33	17.50	.37	1.48	1.30	8.20	22.77	34.38	4.98	5.40
41	Wayland, fresh marsh.	142.50	77.39	.00	.30	.25	.50	2.10	.20	.45	13.05
42	Brick clay, . .	46.00	2.96	.00	.00	.00	.02	.16	15.18	15.83	64.15
56	Charlton, . .	65.13	11.10	3.07	5.62	6.41	9.28	22.51	17.97	3.84	3.57
60	Drift land, . .	25.16	.66	.13	1.08	7.85	61.06	25.82	.53	1.01	.51
64	Amherst subsoil, .	45.00	1.28	.82	2.27	2.26	13.35	29.53	14.40	14.42	12.55
66	Amherst experiment station.	59.01	9.80	.69	3.86	3.63	6.51	36.53	14.27	12.25	9.43
68	Amherst experiment station.	54.75	6.58	.99	1.48	1.53	12.51	28.02	14.51	14.11	10.41
69	Amherst experiment station.	65.25	18.21	1.45	4.40	3.85	12.93	38.13	1.50	.51	12.26
71	Amherst experiment station.	76.60	7.54	1.24	3.62	3.48	11.64	49.01	10.85	1.55	1.71
72	Amherst subsoil, .	86.10	.11	2.25	3.10	2.61	4.13	13.02	12.25	5.30	49.35
96	Franklin, . .	44.60	8.26	4.83	3.83	7.07	6.52	32.91	25.16	1.09	2.12
101	Belmont, . . .	39.33	8.42	8.90	5.59	18.64	26.19	18.48	3.40	2.60	1.63
104	Monson, . . .	37.50	8.98	3.54	2.99	9.16	17.45	19.36	27.94	2.75	3.36

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD; H. T. FERNALD.

Outline of Work.

Four main lines of work have occupied the attention of the entomological division of the station during 1906: correspondence, experimental investigations, special research and the preparation of results for publication.

The correspondence during the year has been unusually large in amount, and has extended over a much longer period than is usual. The largest amount of this work generally comes between the first of May and the end of August, but this year it began in March and continued until into December. Of course during the remaining months numerous letters are received and answered, but the bulk of the correspondence has now not only increased beyond that of previous years, but has extended over a longer period.

No unusual devastation has been reported during the past year, but all of our injurious insects seem to have been abundant, and have caused their share of loss in one line or another.

Experimental investigations have been begun or continued from previous years along a number of lines. The prevalence of the white fly in greenhouses has caused much loss, and information as to the methods of controlling this insect has been in great demand. For this purpose fumigation with hydrocyanic acid gas appears to be the most successful if made at the proper intervals of time and in the proper way; but this gas is also injurious to plants, and how much these can stand under varying conditions of light, temperature, humidity, length of exposure to the fumes, etc., has not been determined for different kinds of plants at different ages. This has accordingly been made a subject of particular investigation during the past year.

Tomatoes were the first crop tested, the usual greenhouse varieties being selected; and the plants were fumigated at all stages of growth and under varying conditions, to determine in each case the maximum amount of gas which could be used without injury. These experiments have now been completed, and demonstrate that it is possible to fumigate tomatoes with a sufficient strength of cyanide to destroy the white fly without injuring the plants, provided certain conditions are carefully observed. The information thus obtained has already been supplied to a number of persons who have had trouble with the white fly in their greenhouses, and has been used successfully, and a bulletin on the subject is now being prepared. At the present time a similar series of experiments with cucumbers, another important forcing-house crop, and one also seriously injured by the white fly, is in progress.

The prevalence of root maggots of various kinds during the past few years has called attention to the need of a more thorough study of the methods for controlling these insects; and a series of tests of these methods was begun last spring, the intention being to try different treatments recommended, and obtain evidence as to their comparative value. For various reasons, however, it was impossible to complete these experiments during the season, and it is planned to repeat them on a larger scale next year.

The last two summers have been unusually favorable for the rapid increase and distribution of the San José scale. This pest has been in Massachusetts for about fifteen years, and in the localities where it was first introduced has spread in all directions for some distance. New centers of infestation, however, have been constantly established from the planting of infested stock of one kind or another; and while five years ago most of these centers were already in existence, the number of scales at each was so small that their presence was generally unsuspected. It would seem that during the first two or three years in any locality this scale spreads but little, as the plant it is on furnishes all the food supply needed; but as these plants become thoroughly covered with the scales, the young find it more difficult to obtain their food without wandering farther from where they were born, and apparently more of them under these conditions get upon the feet of birds or larger insects which alight where they are, and are thus carried away to infest other parts. The result of this is a general infestation of the region, following four or five years after the local infestation; and it is probable that this condition of affairs was reached generally in Massachusetts about 1904. Following this were two summers extremely favorable for a rapid increase of these pests; and we now find them in great abundance in many places where their presence has not before been suspected, and quite generally scattered through the State.

Whether this explanation, which naturally is more or less theoretical, be correct or not, the fact remains that the correspondence of this station shows that the San José scale was probably present in one or more somewhat restricted areas in nearly every town in Massachusetts east of the Connecticut River in 1904; while at the present time it would probably be easy to find it in a dozen places in each of these towns, and as frequently on large, old trees as on recently set ones.

Though this insect attacks a large number of kinds of plants, those of most importance to man are the fruit trees and certain ornamental trees and shrubs; and these, accordingly, are the ones which will receive attention in the way of treatment. A number of extensive studies in the treatment of the San José scale were begun at this station in 1902, at which time the conclusion was reached that the most successful treatment was obtained by the use of the lime and sulfur mixture. Farther experiments along this line have been made as opportunities offered, and the results reached still confirm that conclusion. Last spring over eight hundred trees belonging to the college were sprayed with a number of different preparations, and a study of the results was made during the entire summer and fall. The inconvenience in making the lime and sulfur mixture, resulting from the necessity of boiling the materials for from forty minutes to an hour, has led to an attempt to avoid this by adding materials which would continue the boiling begun by the slaking of the lime for a sufficient length of time to obtain the desired chemical combinations. Several of these "self-boiling mixtures" were tested last spring, but none of them gave as good results as the lime and sulfur mixture prepared in the usual way. Perhaps the best of these "self-boiling mixtures" was that obtained by a mixture of 20 pounds of lime, 14 pounds of sulfur and 10 pounds of sal-soda in 40 gallons of water. Similar combinations, substituting sodic sulfid or caustic soda for the sal-soda, were more expensive and gave less satisfactory results.

The Derror tree fluid was also tested in the course of these experiments, but so far as could be observed failed to be of the slightest benefit in any case.

The K. L. mixture, which has been recommended by the Delaware Experiment Station, also gave unsatisfactory results, besides being quite expensive.

The Rex lime-sulfur solution was applied in four different ways, in accordance with the suggestions of the manufacturers, but none of the four gave satisfactory results, although a small proportion of the scales was killed.

Scalecide, applied at the rate of 1 gallon to 22 gallons of water, proved to be something of an insecticide, killing many of the scales; but applied with the same apparatus, by the same men and on the same day, as the ordinary lime and sulfur mixture, it failed to give anything like as good results. From reports which have been received, however, from other places, it is probable that this material, used at greater strength, in two applications and under great pressure in the pump, may prove quite effective.

Observations for determining dates of appearance of the young of the oyster-shell and scurfy scale have been continued, and the same observations have been made for the white pine scale, as upon the time when the young appear entirely depends the time at which successful treatment can be given.

The raising of cranberries in Massachusetts is a very important industry, in which a large amount of capital is invested, and the annual value of the product is over a million dollars. The cranberry plant has a number of serious insect enemies, and fifteen years ago the subject of cranberry insects was given much attention at this station, and the results obtained at that time were published. Farther study on the subject has been greatly needed, but it was impossible to make these anywhere except on the bogs themselves, and until the present year arrangements for this could not be made. Last spring, however, it was found possible to again take up the study of cranberry insects under the local conditions found on the bogs, and an investigator spent five months in continuous study of these insects on the bogs around Wareham. Many of the problems connected with the control of cranberry pests have been solved, as a result of this investigation; but many new problems have appeared in the course of the work, which make it desirable to continue the study farther, and it is the present intention to have an investigator spend six months at least during the coming year in continuing the observations begun last summer. That the results thus far have been so satisfactory is due in a great measure to the hearty co-operation in the work given by the Cape Cod Cranberry Growers' Association, and of many individuals connected therewith.

During the latter part of last winter some very remarkable cocoons found in Dorchester were sent to this division by the Gypsy Moth Commission, and were found to be the cocoons of some foreign insect. Subsequently the moths which emerged from them were identified as being native in China and Japan, and concerning which very little appears to be known. The possibility that this insect may become a pest in this country is so great that it has seemed wise to thoroughly investigate its present distribution, abundance, probable means by which it reached this country, and all that is already known of it, and this work has taken much of the time during the last two months of this year. Apparently this insect, which may for convenience be designated the Oriental moth, has been in this country for six or seven years, and it is at least possible that it was introduced on nursery stock imported from Japan. It has now spread over a considerable territory in Dorchester, where it is quite abundant. The caterpillar feeds upon the leaves of a large number of our more common fruit and shade trees. While it is yet too soon to determine whether it will become a serious pest, the experience this State has had with the gypsy and brown-tail moths has been of such a nature that it is the part of wisdom to investigate all such importations as this, and be at least prepared for the worst. The insect has already shown that it can live in our climate, that it can become quite abundant, and that it has few if any enemies. At the present time in Asia it is present over twenty degrees of latitude, corresponding to the distance from Florida to Labrador in this country. A bulletin giving all the information thus far obtainable about this insect has already been issued, and further studies of it will be made the coming year.

The other subjects outlined in this report have taken so much time that little has been done along the line of special research, only one paper having been published, though several topics are now in hand, and the work on them occupies the few odd minutes not taken by other duties.

Insects of the Year.

The insects which have caused much loss in Massachusetts during 1906, as indicated by the correspondence of the station and also by personal observation, have been of many kinds. The condition of this State as regards the San José scale has already been described, and the correspondence about this pest has been very great in amount. In connection with this, the oyster-shell scale, the scurfy scale, the rose scale, the white pine scale and several kinds of Lecaniums have required a considerable amount of attention. Many letters with reference to the gypsy moth and brown-tail moth have also been received, and have either been answered from here, or the writers referred to the Gypsy Moth Commission, which now has charge of the work of controlling these insects. The elm-leaf beetle is gradually becoming more abundant, and has again reached the point where its numbers are sufficient to greatly injure the appearance of our elms. During the spring months an unusual abundance of the spiny elm caterpillars was noticed, and in some places they seriously injured the appearance of the trees. Plant lice of various kinds were also much in evidence; and many specimens of tussock moths, particularly the old tussock moth, were sent to the station for identification. Many inquiries about cutworms were received, but the correspondence on this topic was less than during the two years preceding; while inquiries about wire worms and the best treatment for them were more abundant than usual. In greenhouses the white fly is a serious pest, causing the loss of thousands of dollars, and much correspondence; while thrips, which was so much in evidence a few years ago, was inquired about but twice. The asparagus root miner, an insect not hitherto reported in this State, has made its appearance in several places in sufficient abundance to cause considerable injury. But little is known of the life history of this insect, and further investigations upon it are planned for the coming season.

As a whole, the important insects this year have been of so many different kinds that it has been impossible to give to most of them the uninterrupted attention which is needed, even for our most abundant forms, in order to test the best methods of control. There is no insect known about which more information would not be of assistance in leading to the discovery of better remedies than we now have; and it is most desirable that the insects causing the most loss in any year shall be carefully studied at the time, in the hope of finding better methods of control. Such conditions as have prevailed during the past season, therefore, where work of this kind has been almost impossible on account of so many calls for information in different directions, produce a year which must be considered as more or less unsatisfactory in the way of results; and this was certainly the case in 1906.

VETERINARY DEPARTMENT.

This newly organized department of the station has been in operation since July 1 of the present year. Previous to this the veterinary work in the station has been attended to by the veterinary department of the college.

Each year for the past fifteen years there has been an increasing demand from the stock owners of the State for information concerning veterinary subjects. This demand has come to the station in the form of requests for lectures and publications, and correspondence relative to animal diseases, or to the nature of material sent for examination. The specimens that have been received have come from various parts of the State, and have consisted of diseased tissues of the larger animals, or in some instances the cadavers of the smaller farm animals; and in some cases the products of the animals, such as milk, eggs, etc. This material has been subjected to a close examination, oftentimes a microscopical study and bacteriological examination, requiring a large amount of time and labor to complete it. Living animals sent for study and examination have been kept under observation in the hospital, where experiments have been conducted to obtain definite information regarding the nature of the particular affection, as regards cause, effects, contagiousness and other closely related matters. Upon the completion of the work written reports have been sent to those from whom the specimens have come, advising them of the nature, cause, treatment or prevention of the particular affection.

On several occasions visits have been made to farms in different parts of the State, to investigate outbreaks of disease of a character peculiar either on account of the circumstances under which the disease made its appearance, the form it assumed, or the peculiarity of the symptoms accompanying its development. Experiments conducted at the station, and on the farm in conjunction with the owners of the animals, have in several instances been fruitful of most favorable results, either in arresting the progress of the disease or in preventing its recurrence.

REPORT OF THE HORTICULTURIST.

F. A. WAUGH.

Outline of Work.

The work of the department of horticulture continues on the lines laid down several years ago, and set forth in previous reports of this station. The principal experiments undertaken deal with problems in the propagation of fruit trees, in pruning, and in the systematic study of varieties of fruits. These all require a considerable number of years to secure definite results, and no report on these experiments would be justified at this early date.

Incidental to other work, a few experiments of minor importance have been underway, such as cross-grafting herbaceous plants, test of varieties of strawberries, details of certain methods in market-garden practice, some study of thermo-physiological constants, the practical application of digesting fluids in the germination of seeds, the growing of mushrooms, etc. A short report on the experiment last mentioned is appended herewith.

Notes on Mushroom Culture.

Opportunity has offered during the last two years to make several practical experiments in mushroom culture. The principal matter at issue, aside from a demonstration of methods, was the comparative value of the new pure-culture spawn. Several commercial varieties of these so-called tissue or pure-culture spawn were tested and compared, and comparison was made with the common commercial English spawn and with the French spawn. The results are summarized below.

Mushrooms were grown under the ordinary conditions. No special houses were provided. For the most part, beds were made up under greenhouse benches in a house used for bedding out stock. In one instance beds were made in an unused cellar. This work was under the direct charge of Mr. Francis Canning, head gardener.

As has been said, the usual methods were followed. For instance, in the fall of 1904 a bed was made up, November 19. This was spawned November 30 with common English spawn and with a few varieties of pure-culture spawn. The first picking was made on January 6. The entire crop from a bed of 75 square feet was something over 50 pounds. This amount was sold for an average of 35 cents a pound, bringing a total of a trifle over $17.50. This gives an average return of approximately 24 cents per square foot. Part of this crop was sold locally in quart strawberry boxes, which will hold one pound of mushrooms when heaping full. A considerable amount of the crop was shipped to Boston, selling from 40 to 50 cents a pound, yielding a net average of 33 cents a pound.

In the fall of 1905 the experiment was renewed, greater care being taken to equalize all conditions, and to give a fair test on the comparative value of varieties used. Five pure-culture varieties were included in this planting, as follows: Alaska, Columbia, Bohemia, Galloway and Agaricus arvensis (this last is the variety now called Eureka). In separate sections of the same bed the common English and the French spawns were included. The following table shows the results of this experiment. The time of first picking is indicated, and of the last picking, thus showing the length of season. The total weight is given, and dates are added to indicate at what time of the season the beds were most productive. In the last column is shown the number of pounds produced by each bed during its most productive week.

Comparison of Varieties, 1905–06.

VARIETY.	Spawned.	First Picking.	Last Picking.	Total Weight.	Square Feet of Bed Surface.	Weight per Square Foot of Surface (Pounds).	Week most Productive.	Amount for Week (Pounds).
Alaska,	Oct. 26,	Dec. 11,	March 10,	7 lbs. 4 oz.,	9	.777	Dec. 11–18,	3.375
Galloway,	Oct. 26,	Dec. 16,	Jan. 25,	3 lbs. 8 oz.,	9	.388	Dec. 23–30,	2.000
Columbia,	Oct. 26,	Dec. 16,	March 10,	6 lbs. 4 oz.,	9	.666	Dec. 29–Jan. 9,	2.500
Bohemia,	Oct. 26,	Dec. 15,	March 10,	5 lbs. 14 oz.,	9	.555	Dec. 27–Jan. 2,	2.125
Arvensis,	Oct. 26,	Dec. 15,	March 10,	13 lbs. 14 oz.,	9	1.555	Dec. 23–30,	5.500
English,	Nov. 3,	Jan. 8,	March 10,	4 lbs. 12 oz.,	18	.222	Feb. 10–17,	1.500
French,	Nov. 3,	Feb. 24,	March 10,	8 oz.,	18	.027	March 10,	.375

It will be seen that the pure-culture varieties gave much larger yields than either the English or the French spawn. While this difference is very great in this experiment, indicating probably an inferior grade of English and French spawn, all our experiments have shown a similar advantage for the pure-culture varieties. Indeed, it seems to be one of the chief advantages of the new method of growing mushroom spawn from pure culture that it nearly always gives fresher and more vigorous spawn. The product is nearly always more uniform, and of higher quality; but, while this advantage is important, it is not so great as the one already mentioned.

A comparison of the different varieties shows that Eureka (Agaricus arvensis) leads all the others in productivity, Alaska coming second. This has been the result in all the experiments in which these varieties have been tested. Eureka is darker colored than any of the other varieties, and sometimes not quite so well shaped; nevertheless, it is solid and heavy, and of fairly good quality when cooked. Galloway is a white, small, delicate variety, the best of all for eating, but not sufficiently productive to pay the grower.

The following conclusions may fairly be drawn from the experiments: —

1. Pure-culture spawn is as a rule very much better than either English or French spawn.

2. There are important points of difference between the commercial pure-culture varieties; these differences consist in color, flavor, form, and above all else in productivity.

3. The most productive variety thus far tested is Eureka. Several other varieties are promising.

As a general result of our experience, it may be said that mushrooms can often be grown profitably as a catch-crop in cellars or under greenhouse benches where conditions are favorable. The most important favorable condition to be considered is a cheap and reliable supply of fresh horse manure. It is quite plain, however, from our experience, that the stories of sudden wealth accumulating from mushroom-growing are mostly fictitious.

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HATCH EXPERIMENT STATION

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Bulletins and Reports, 1888-1907

AMHERST, MASSACHUSETTS
1907

Bulletins

Reports

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